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Federal Commodity Programs and Returns to Irrigation in the West

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This report exam irrigation in the western United S land, management, fixed capital, and rop alternatives. Commodity market returns and program revenues per unit of applied irrigation water are estimated by field crop and subregion. Two representative study years - 1984 and 1987 - highlight the effect of differing commodity prices and program support levels under extreme market conditions. Aggregate returns to irrigation in western field-crop production were fairly constant over the two study years, averaging $33 per acre-foot of water. Program revenue contributions per unit-water were highest in the Southern and Northern Plains, and lowest in the Northern Mountain and Northern Pacific regions. Commodity programs had the greatest impact on returns to irrigation in rice and cotton production. Program contributions per unit-water were relatively low for the major food and feed grains in 1984; contributions increased significantly with expanded deficiency payments and program enrollment in 1987. Under less favorable market conditions, positive returns to irrigation were largely dependent on commodity program supports. Commodity policy reform increases opportunities for water conservation in western irrigated agriculture.

Keywords: Irrigation, farm programs, commodity programs, support payments, production returns, water use, conservation

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Summary

This report examines the impact of Federal commodity programs on returns to irrigation in the western United States. Returns to irrigation are defined as average returns to land, management, fixed capital, and water (above variable water cost), net of returns to dryland crop alternatives. Market-based returns and commodity program revenue contributions are estimated per acre-foot of applied water, by western subregion and major field crop. Two representative study years - 1984 and 1987 - highlight the effect of differing commodity prices and program support levels under extreme market conditions. Program revenue contributions include deficiency payments and commodity loan supports (above market price), adjusted for compliance costs and forgone returns on set-aside acres, and net of contributions to dryland production.

Aggregate returns to irrigation in western field-crop production remained relatively stable over the two study years, declining from $34/acre-foot (af) in 1984 to $31/af in 1987. However, modified program provisions and market conditions resulted in a substantial shift in the share of returns attributable to Federal commodity programs. Under favorable market conditions in 1984, program revenue contributions accounted for $8/af, or 7 percent of revenues per unit of water applied. Program contributions increased to $22/af in 1987 - or 20 percent of revenues per unit-water - with lower market prices, higher deficiency payments, reduced opportunity costs of acreage set-aside, and expanded enrollment of irrigated base acreage. Under weak market conditions in 1987, positive returns to irrigation were largely dependent on commodity support payments.

The effect of commodity programs on returns to irrigation differed across western production regions. Program revenue contributions per unit-water were largest in the Southern and Northern Plains due to extensive acreage in irrigated program crops and generally high program participation. Lower program contributions in the Northern Pacific and Northern Mountain regions reflect limited acreage shares in eligible program crops, lower deficiency payments per irrigated acre, reduced enrollment of irrigated lands, and relatively small return differentials between irrigated and dryland crop production.

Commodity program impacts on returns to irrigation varied significantly by program crop. Program contributions per unit-water were greatest for irrigated rice and cotton production, reflecting high deficiency payments and program enrollment in each of the study years. Program contributions were lower for the major grain commodities - corn, wheat, barley, and sorghum - under favorable market conditions in 1984. However, commodity supports per unit-water increased substantially with expanded deficiency payments and enrollment under the 1987 wheat and feed grain programs.

Commodity policy reform enacted under the 1985 and 1990 farm legislation increases opportunities for agricultural water conservation. Lower target prices, fixed payment yields, restricted payment acres, and more stringent conservation compliance requirements limit program revenue contributions per unit of water applied. Meanwhile, fixed payment yields, partial payments on idled acres, and expanded crop-flexibility provisions sever the linkage between program benefits and base acreage production. Lower program supports and the decoupling of program benefits from production should reduce water-use incentives for program crop production, thereby encouraging conservation of limited water supplies. Conservation benefits may be enhanced through a broader integration of Federal commodity and water policies that targets critical need areas and facilitates water transfers to satisfy those needs.

Federal Commodity Programs and Returns to Irrigation in the West

Marcel P. Aillery[1]

Introduction

Agriculture in much of the arid western United States depends on water for irrigation. Irrigated agriculture accounts for roughly 80 percent of total water consumption in the West (Solley and others, 1993). However, continued urbanization is likely to increase regional water demand in municipal, industrial, and environmental uses. Since opportunities for large-scale water-supply development are limited and politically untenable, additional water demands will have to be met largely through conservation and reallocation of existing supplies. As irrigation is the predominant water use, much of the reallocated supply will come from irrigated agriculture.

Federal commodity programs - through provisions on land use, crop choice and production returns - alter incentives for agricultural production and irrigation water use (see box, "Commodity Programs and Water Use.") While commodity programs are generally designed with little regard to their effect on water demand, attention has focused recently on the implications of Federal farm policy for resource use and quality (Just and Bockstael, 1990). As competition for existing water supplies intensifies, the benefits of efficient water use increase and an understanding of farm policy effects on water-use decisions becomes more critical.

This report examines the impact of Federal commodity programs on field-level returns to irrigation in the West. Analysis focuses on commodity program revenue contributions per unit-water applied in irrigated agriculture, and potential effects of commodity policy on irrigation water use. Specific objectives of the report are:

(1) To provide estimates of shortrun, average returns to irrigation across major field crops and multistate regions of the West.

(2) To identify that portion of returns to irrigation attributable to Federal commodity payments, across regions and crops.

(3) To discuss implications of commodity policy reform for water conservation and allocation in the West.

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Commodity Programs and Water Use

Commodity programs administered by the U.S. Department of Agriculture are a central feature of Federal farm policy (USDA, 1990). Under the commodity programs, market-price movements for major crop commodities may be tempered through management of government-held stocks and restrictions on acreage planted. Program objectives include farm income enhancement and stabilization, food supply security, farm export expansion, and more recently, protection of the Nation's soil and water resources.

The Acreage Reduction Program (ARP), which is the primary mechanism of commodity supply control, establishes acreage set-aside requirements for eligible program crops. Voluntary compliance with acreage set-asides and other conservation provisions entitles producers to price and income supports under the commodity programs. Price support is provided through guaranteed farm loans at planting time. Producers may either repay loans at the announced loan rate, or exchange commodities valued at the loan rate if market prices fall. Income support is provided through direct "deficiency payments" to producers. Deficiency payment rates, based on the difference between target price and the higher of market price and loan rate, are applied to qualifying production on program base acres by farm.

The growth in western agricultural water demand has been attributed in part to favorable incentives under the Federal commodity programs (Lee and Lacewell, 1990; Just and others, 1991). High income and price supports - combined with production-indexed payment provisions prior to 1985 - increased irrigated crop returns relative to dryland production. Irrigated acreage expanded through dryland acreage conversion and development of new cropland, while higher returns per unit-yield encouraged intensive water use or irrigated lands. Acreage set-aside requirements favored substitution of water for land, where fixed water supplies (due to legal entitlements or pump capacity limits) could be applied over fewer acres. Modified crop-market prices and water-supply development incentives affected water use for program participants and nonparticipants.

The effect of commodity supports on water use was partly offset by mitigating factors related to the commodity programs. Set-asides reduced acreage that might be irrigated, potentially lowering the demand for water. (Water rights were not necessarily idled; limited irrigation may be required for set-aside cover crops while unused water supplies could be applied to other acreage, subject to conveyance systems and legal provisions.) Accelerated adoption of water-conserving technologies may have further reduced water demand on acres irrigated. Program incentives for technology adoption included increased investment capital (and credit access) through guaranteed deficiency payments, higher potential program payments with improved crop yields, and increased market revenues due to price supports. Set-aside requirements, planting flexibility provisions, and changes in relative crop returns have likely influenced regional cropping patterns, with resulting adjustments in irrigation requirements.

From a resource policy perspective, water use incentives under the Federal commodity programs have conflicted with Federal and State conservation objectives for water-scarce areas. Policy reform under the 1985 and 1990 farm legislation sought greater consistency across commodity and resource policy goals by reducing support levels for program production and decoupling program benefits from input-allocation decisions. Although water use is not explicitly addressed under the commodity programs, commodity reform measures may serve to reduce irrigation water demand while minimizing income effects on the western agricultural sector. Regional potentials for water conservation will depend, in part, on irrigated agriculture's traditional reliance on support payments under the commodity programs, as examined in this report.

Analytical Framework

Returns to irrigation water are estimated based on a *partial, budgeting* analysis of commodity market returns and commodity program revenues under irrigated and dryland field-crop production. Returns to irrigation are defined as returns to land, management, fixed capital, and water (above variable water cost), net of returns to dryland crop alternatives. Market and program revenues above variable costs for irrigated (harvested) production, less revenue and costs under dryland alternatives, are computed per unit-water applied. Commodity program revenue contributions include deficiency payments plus commodity loan supports (above market price), adjusted for compliance costs and forgone returns on set-aside acres, and net of contributions to dryland production.

The partial nature of the analytical framework precludes a full examination of farm program impacts on agricultural income and water use. Estimated returns to irrigation represent private, shortrun average returns at the field level, given observed crop prices and crop acreage allocations. Commodity program contributions do not reflect other Federal payments and subsidies to the farm sector[2], or market adjustments from equilibrium conditions in the absence of farm programs. Moreover, return estimates do not capture potential irrigation benefits across farm enterprises (e.g., crop rotations, livestock) or irrigation effects on producer risk. The broader societal costs and benefits of water use in irrigated production are also not considered.

Returns to irrigation are reported by production region and major field crop, based on acreage-weighted aggregations of state-level budget data across program and nonprogram production. Alternative estimates for the 1984 and 1987 production years highlight the effect of differing commodity prices and program support levels under extreme market conditions.

Returns to irrigation were evaluated for 10 crop commodities, representing primary U.S. field crops. "Farm program" crops include wheat, corn (for grain), sorghum (for grain), cotton, rice, barley, and oats. "Nonprogram" crops include alfalfa hay, other hay and soybeans.[3] While commodity program provisions do not directly affect returns for nonprogram crops, these crops are included as they are often substitute crops and account for significant water use in the West.

Six western production regions were defined based on comparable climate, cropping patterns, and production practices. Study regions include the Northern Plains (North Dakota, South Dakota, Nebraska, Kansas), Southern Plains (Oklahoma, Texas), Northern Mountain (Montana, Wyoming, Idaho, Utah, Colorado), Southern Mountain (New Mexico, Arizona, Nevada), Northern Pacific (Washington, Oregon), and Southern Pacific (California) regions (fig. 1).

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[2] In particular, commodity program revenue contributions do not include USDA payments for export enhancement, disaster relief, conservation, and cropland idled (other than annual commodity set-aside acreage).

[3] While commodity loan guarantees are available to soybean producers, soybeans do not qualify for program deficiency payments (i.e., target prices and acreage set-aside requirements are not specified).

Figure 1.

Western production regions defined in study

Procedures

Selection of study years. Irrigation return estimates for alternative production years - 1984 and 1987 - reflect the impact of markedly different market conditions and commodity program support levels. In 1984, market prices were favorable across major program commodities while commodity supports were relatively low. By contrast, the 1987 production year is characterized by low market prices across the major feed grains and larger commodity program supports. While factors other than market price and program payments can influence returns to irrigation, these study years represent a range of returns under market condition extremes.

Selection of representative study years was based on a three-step procedure. First, deficiency payment rate as a share of market price, or "deficiency payment-market price" ratio, was computed by program crop for the 10 most recent production years, 1984-93 (see appendix table 4 for crop prices and deficiency payment rates by year). Second, production years were evaluated according to overall market conditions and program support levels. Each production year was ranked from 1 (low program/high market) to 10 (high program/low market) based on a simple averaging of "deficiency payment-market price" ratios across program crops by production year. Finally, representative study years were selected based on (1) production-year rankings for extreme market/program levels and (2) best available data for irrigation cost-return calculations. Production-year 1984 had the lowest program/market ratio of the 10 years considered. Production-year 1987, with the second highest ratio, was selected to represent the high program/low market case due to disaggregation of program data specific to irrigated production. (For an overview of commodity programs, market shifts, and irrigated acreage, see box, "Commodity Programs - An Historical Context.")

Calculation of returns. Calculation of returns to irrigation involved a three-stage process, consistent with recommendations of the U.S. Water Resources Council (Gibbons, 1986). First, crop returns *per acre* were compiled for irrigated and dryland production at the state level. Crop returns are defined as average returns to land, management, fixed capital, and water (irrigated crops), and are calculated based on combined market and commodity program revenues above variable production costs per crop acre. Program revenue contributions include average deficiency payment per harvested program acre[4], plus commodity loan support payments (where loan rate exceeds season-average market price), less conservation compliance costs and forgone returns on set-aside acres, weighted by share of harvested acreage enrolled by crop and State. Market returns include per-acre yields valued at the market price, less variable costs of production. Market returns and program revenue contributions are *ex post* values, and do not necessarily reflect expected preseason returns to irrigation.

Second, crop returns were computed *per irrigated acre, net of dryland* production returns. Returns to irrigation are based on the difference in net returns between a given irrigated crop and the predominant dryland (nonirrigated) crop alternative. The incremental return attributable to irrigation reflects increased market revenues due to higher yields, often higher production costs with more intensive input use (e.g., water, machinery, applied chemicals), and differences in commodity program payments across irrigated and dryland production.

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[4] Deficiency payments per harvested acre for the 1984 and 1987 production years do not include partial payments under the 0/92 and 50/92 provisions, nor adjustments in eligible payment acres for "normal flex" after 1990.

Commodity Programs - An Historical Context

The effect of Federal commodity programs on irrigated agriculture reflects changing market conditions and program provisions over time. During the early 1980's, program participation was relatively low as producers expanded planted acreage to take advantage of favorable market conditions and credit access. High market prices reflected strong demand and reduced stocks of major farm commodities. U.S. acres irrigated peaked at 52 million in 1981, following a decade of steady expansion (USDA, 1993). By the mid-1980's, the agricultural policy environment had changed significantly. Commodity prices fell in response to expanded supplies of major crop commodities and weak world demand. Lower farm earnings and rising farm debt contributed to deepening financial stress in rural areas, despite substantial growth in Federal commodity program expenditures. Meanwhile, public attention focused increasingly on environmental consequences of farm policies (USDA, 1990).

The 1985 Food Security Act modified commodity programs to reflect emerging priorities. The Acreage Reduction Program was maintained, with a sharp decline in loan rates (price support) and a phased reduction in target prices (income support) to reduce Federal expenditures and increase market orientation of commodity programs. Limits on deficiency payments - including fixed program yields and partial payments for idled payment acres - further restricted Federal outlays while decoupling program benefits from production decisions. Conservation compliance provisions tied commodity program benefits to protection of natural resources, primarily through soil-erosion control. The Conservation Reserve Program (CRP) provided for the voluntary idling of environmentally sensitive cropland under a 10-year agreement, with producer payments established through a competitive bid process.

Despite reform measures under the 1985 farm bill, weak market conditions across food and feed grain crops resulted in higher deficiency payment rates and lower opportunity costs of cropland set-aside. Commodity program participation expanded as producers relied increasingly on deficiency payments to offset expected reductions in market returns. Low market prices, expanded program enrollment, higher mandatory set-aside requirements, and acreage idling provisions all contributed to a decline in cropland irrigated during the mid-1980's.

Federal commodity supports were further reduced under the 1990 Farm Act and the Agricultural Reconciliation Act of 1990. The 1990 Farm Act fixed target prices at roughly 90 percent of peak 1985 levels, although production costs had increased. Program payment yields remained frozen at 1985 levels despite a continuing upward trend in actual yields (Westcott, 1993). Loan rate and marketing loan provisions were introduced for selected crops to maintain market competitiveness, while commodity program eligibility was tied to more stringent conservation compliance provisions. The Agricultural Reconciliation Act of 1990, which implements the 1990 deficit reduction agreement, further restricted commodity program contributions by eliminating deficiency payments on a share of base acreage and expanding cropping flexibility to increase market revenues and rotation incentives. U.S. acreage irrigated expanded through the latter 1980's and early 1990's, due in part to reduced program enrollment incentives and more favorable market conditions after 1987.

Crops may be produced under both irrigated and dryland technologies (e.g., irrigated and dryland corn) where natural precipitation provides adequate soil moisture for crop growth. In more arid areas of the West, however, dryland production of a given crop may be infeasible or unlikely. In such cases, returns to irrigation are calculated based on irrigated crop returns, less returns for a representative dryland crop alternative (e.g., irrigated corn and dryland sorghum).

Third, average returns to irrigation were estimated *per unit-water*. Return per unit-water is calculated by dividing the irrigated-dryland return differential by applied water per acre, for each irrigated crop and State. Water-use estimates represent water applied at the field level, after water conveyance losses and unadjusted for irrigation drainage return flows.

Returns to irrigation presented in this report necessarily reflect underlying procedural and definitional assumptions. See Appendix A for a review of study data sources, assumptions, and equations used in cost-return estimation.

Commodity Programs and Returns to Irrigation

This section presents estimated shortrun average returns to irrigation in western field-crop production, evaluated in the context of changing market conditions and commodity program supports. Average variable cost and return per unit of irrigation water applied (net of costs and returns to dryland crop alternatives) are summarized by region and field crop for the 1984 and 1987 production years (table 1 and fig. 2).[5]

Overview of Findings

Aggregate westwide returns to irrigation per acre-foot (af) of applied water were remarkably stable over the 2 years studied. In 1984, irrigation contributed an estimated $34/acre-foot (af) (above water cost) to the value of western field-crop production. Under less favorable market conditions in 1987, returns to irrigation declined slightly to $31/af as increased commodity supports and reduced dryland opportunity costs offset the effect of reduced market revenues for irrigated production.

Returns to irrigation varied substantially by western subregion, both within and across study years. Regional variation reflects local differences in irrigated cropping patterns, water cost and application rates, crop yields, market prices, and relative profitability of dryland crop alternatives. In addition, commodity program contributions differed significantly due to variation in acreage shares for eligible program crops, support levels and set-aside provisions by program crop, and enrollment rates for program-crop production.

In general, returns to irrigation were greatest in the Northern Plains, Southern Pacific, and Southern Plains regions due to higher irrigated/dryland return differentials and large acreages in higher-valued field crops. Lower returns in the more temperate Northern Mountain and Northern Pacific regions reflect extensive irrigation of lower-valued small grain and hay crops, and relatively high returns under dryland production alternatives. Intensive consumptive requirements depressed irrigation returns per unit-water in the more arid Southern Mountain region, although crop returns per irrigated acre were high.[6] The Northern Plains had the largest combined market and program return to irrigation in field-crop production over the 2 study years - $47/af[7] - followed by the Southern Pacific ($44/af) and Southern Plains ($42/af) regions. Returns to irrigation were lower in the Southern Mountain ($20/af), Northern Mountain ($16/af), and Northern Pacific ($12/af) regions.

Cotton accounted for the largest average return to irrigation ($77/af) among field crops, followed by irrigated corn ($64/af) and rice ($59/af). Other grain crops that are storable and readily produced with natural moisture over much of the United States - including sorghum ($29/af), wheat ($12/af),

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[5] For irrigation costs and returns *per acre* by region and crop, see app. table 6 and app. fig. 1.

[6] Relative returns to irrigation (per unit-water applied) may contrast significantly with relative crop returns per irrigated acre (app. table 6) due to variation in water application rates and dryland production possibilities across irrigated crops and regions.

[7] Values represent an acreage-weighted average of 1984 and 1987 study year estimates from table 1, column 6.

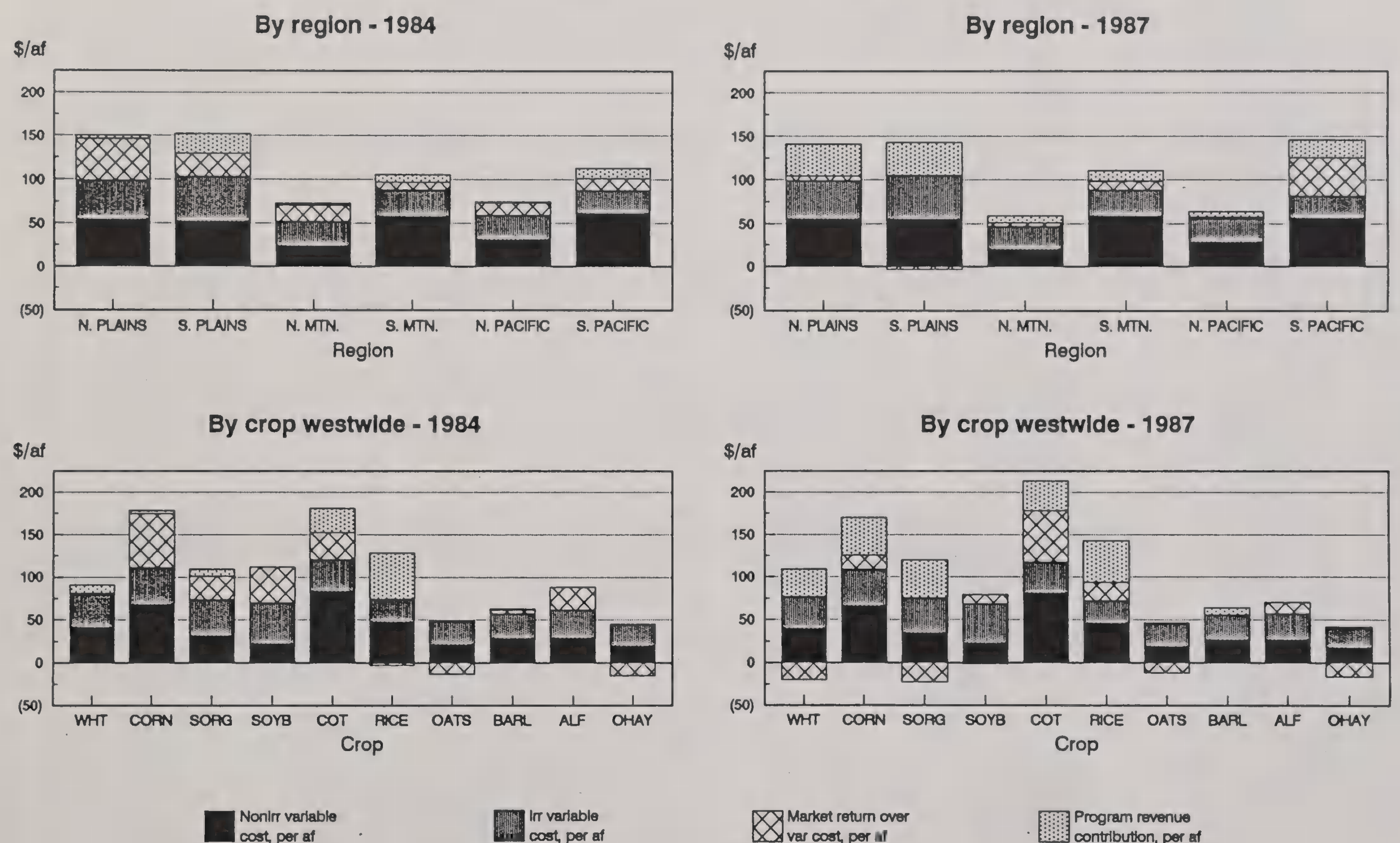
Table 1 -- Average variable cost, market return, and commodity program revenue contribution per unit-water applied in irrigated field-crop production, by western region and crop westwide, 1984 and 1987 1/

		(1) Variable irrigation cost per af	(2) Total variable cost (TVC) per af	(3) Market revenue per af	(4) Commodity program revenue per af	(5) Market return above TVC per af (3)-(2)	(6) Combined return above TVC per af (4)+(5)	(7) Program revenue as a share of combined revenue (4)/(3+4)
		$/af	$/af	$/af	$/af	$/af	$/af	Pcnt
1984	All field crops, westwide	36.10	82.20	108.60	7.90	26.40	34.30	6.8
	All field crops, by western region							
	N. Plains	44.40	99.10	146.70	4.20	47.60	51.80	2.8
	S. Plains	50.10	103.50	129.60	22.80	26.10	48.90	15.0
	N. Mountain	28.10	52.40	71.20	2.00	18.80	20.80	2.7
	S. Mountain	29.70	88.40	97.20	8.80	8.80	17.60	8.3
	N. Pacific	27.70	59.90	74.10	0.90	14.20	15.10	1.2
	S. Pacific	25.80	88.00	101.60	11.80	13.60	25.40	10.4
	By field crop, westwide							
	Wheat	37.80	79.30	81.40	9.30	2.10	11.40	10.3
	Corn	43.10	110.80	174.30	4.00	63.50	67.50	2.2
	Sorghum	42.20	73.90	101.10	8.40	27.20	35.60	7.7
	Cotton	36.30	120.30	152.40	28.30	32.10	60.40	15.7
	Rice	26.20	74.10	70.70	54.00	-3.40	50.60	43.3
	Barley	28.80	57.10	61.50	1.20	4.40	5.60	1.9
	Oats	26.80	48.50	35.00	0.20	-13.50	-13.30	0.6
	Soybeans	47.50	69.60	111.70	--	42.10	42.10	--
	Alfalfa hay	32.40	61.50	88.40	--	26.90	26.90	--
	Other hay	25.40	45.40	30.40	--	-15.00	-15.00	--
1987	All field crops, westwide	34.50	78.00	86.80	22.20	8.80	31.00	20.4
	All field crops, by western region							
	N. Plains	43.10	99.30	104.70	36.60	5.40	42.00	25.9
	S. Plains	49.70	105.40	102.60	37.70	-2.80	34.90	26.9
	N. Mountain	25.90	47.00	51.60	7.70	4.60	12.30	13.0
	S. Mountain	29.60	88.90	99.10	12.10	10.20	22.30	10.9
	N. Pacific	26.90	56.30	58.30	6.10	2.00	8.10	9.5
	S. Pacific	25.30	82.10	125.60	20.50	43.50	64.00	14.0
	By field crop, westwide							
	Wheat	36.40	76.70	55.60	32.80	-21.10	11.70	37.1
	Corn	42.50	108.80	125.90	44.20	17.10	61.30	26.0
	Sorghum	41.00	75.70	53.10	44.50	-22.60	21.90	45.6
	Cotton	36.30	117.60	178.20	35.30	60.60	95.90	16.5
	Rice	26.20	72.30	93.70	49.20	21.40	70.60	34.4
	Barley	28.30	55.60	55.10	8.50	-0.50	8.00	13.4
	Oats	26.90	46.10	34.20	0.20	-11.90	-11.70	0.6
	Soybeans	45.40	68.50	79.60	--	11.10	11.10	--
	Alfalfa hay	29.60	56.90	70.80	--	13.90	13.90	--
	Other hay	24.40	42.30	25.70	--	-16.60	-16.60	--

1/ Estimates are net of dryland cost/returns, and acreage-weighted across program and nonprogram production.

FIGURE 2

Average cost and return per unit-water in irrigated field-crop production



barley ($7/af), and oats (-$13/af) - had lower returns to irrigation. Among nonprogram field crops, average returns to irrigation were highest for soybeans ($27/af) and alfalfa ($20/af). Negative returns to irrigation for oats and other-hay suggest that dryland production, in the aggregate, was more profitable under prevailing market conditions, and that low returns to irrigation may be offset by risk considerations involving livestock forage production.

Commodity program revenue contributions. Differing market conditions and commodity support levels over the 2 study years resulted in a substantial shift in the share of returns to irrigation attributable to Federal commodity programs. In 1984, commodity programs contributed an estimated $8/af in irrigated field-crop production westwide (above contributions to dryland crop alternatives), or 7 percent of revenue generated per unit-water applied. Under less favorable market conditions for major food and feed grains in 1987, returns to irrigation were much more dependent on commodity programs. While the share of irrigated acreage in program crops declined, total program revenues expanded with higher deficiency payment rates, reduced opportunity costs of acreage set-aside, and increased enrollment of irrigated base acreage. Aggregate westwide program contributions rose to $22/af, or 20 percent of revenue generated per unit-water applied.

The relative effect of commodity supports on returns to irrigation varied across western production regions. Average program revenue contributions over the 2 study years were greatest in the Southern Plains ($30/af) and Northern Plains ($21/af)[8], reflecting extensive acreage in eligible program crops and high rates of irrigated enrollment. Commodity programs had a smaller impact on returns to irrigation in the more humid Northern Mountain ($5/af) and Northern Pacific ($3/af) regions due to large irrigated acreage in nonprogram crops, lower deficiency payments and enrollment for irrigated program-crop acreage, and relatively high payments and enrollment for eligible dryland acreage. Higher program revenue contributions in the arid Southern Pacific ($16/af) and Southern Mountain ($10/af) regions are attributable to heavy enrollment in the cotton program.

The importance of commodity program supports varied significantly by crop. Average program revenue contributions were greatest for rice ($52/af) and cotton ($32/af), reflecting high program payments and enrollment in each of the study years. Average program contributions were less for the major grain commodities - wheat ($20/af), corn ($25/af), and sorghum ($25/af) - although expanded payment rates and enrollment under poor market conditions in 1987 resulted in sharply increased support levels. Program revenue contributions were lowest for irrigated barley ($5/af) and oats ($0/af).

The percentage share of revenues attributable to commodity programs highlights the relative importance of market and program contributions to returns to irrigation across irrigated program crops. Rice production accounted for the largest program revenue share (39 percent) over the 2 study years[9], followed by irrigated sorghum (24 percent) and wheat (23 percent). Large program contributions for irrigated cotton accounted for a relatively small share of total revenues (16 percent) due to favorable cotton market prices in both study years. Program revenue contributions comprised a lesser share of total revenue for irrigated corn (14 percent), barley (7 percent), and oats (1 percent).

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[8] Values represent an acreage-weighted average of 1984 and 1987 study year estimates from table 1, column 4.

[9] Values represent an acreage-weighted average of 1984 and 1987 study year estimates from table 1, column 7.

In many cases, higher deficiency payments under irrigated production (relative to dryland production) represented a substantial share of positive *net returns* to irrigation. Indeed, the viability of irrigation for marginal field crops - and major crops under depressed market conditions - was often dependent on commodity program supports. Return estimates suggest that without commodity programs, much of the irrigated acreage in rice, wheat, barley, sorghum, and oats would revert to alternative irrigated crops or to dryland production, as market prices alone have not been sufficiently high in all years to cover the higher costs of irrigated production.[10]

Returns to Irrigation by Western Region

The following discussion, organized by western production region, assesses the relative contribution of Federal commodity programs to returns to irrigation over the 1984 and 1987 study years. Primary factors underlying regional variation in returns are highlighted in table 2.

Northern Plains. Commodity program effects on returns to irrigation in the Northern Plains varied significantly with grain market conditions. Program revenue contributions of $4/af (3 percent of total revenue)[11] in 1984 reflect moderately low deficiency payments and enrollment in irrigated grain production. Combined market and program revenue contributions were highest among regions, due largely to favorable market prices for corn and soybeans. In 1987, program contributions increased to $37/af (26 percent) with higher deficiency payments, reduced opportunity costs of acreage set-aside, and near-full enrollment across irrigated grain crops. Total returns to irrigation remained strong as expanded program supports offset the loss in market revenues (fig. 3).[12]

Southern Plains. Commodity programs had a major impact on returns to irrigation in the Southern Plains. Program revenue contributions of $23/af (15 percent) in 1984 were largest among regions, reflecting extensive acreage in eligible program crops coupled with high deficiency payments and enrollment. Higher total returns to irrigation reflect large program contributions, favorable market prices for cotton and grains, lower dryland yields under moderate drought conditions, and high productivity of applied water.[13] In 1987, returns to irrigation declined with reduced market prices for grain and hay crops and higher dryland yields. However, program contributions increased to $38/af (27 percent) with expanded deficiency payments and enrollment. Negative market returns to irrigation suggest that dryland production was generally more profitable under prevailing prices, and that commodity program supports were needed to achieve positive returns to irrigation.

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[10] While crop market returns per *irrigated acre* were generally positive under poor market conditions, negative market returns per *unit-water* for some crops indicate low aggregate returns to irrigated production relative to dryland cropping alternatives.

[11] Percentage values in parentheses here (and throughout the discussion of returns by region and field crop) indicate the share of total revenue attributable to commodity programs.

[12] Sustained irrigated acreage expansion in the Northern Plains - due in part to strong returns to irrigation - contrasts with other western regions where irrigated acreage has stabilized or declined.

[13] High returns per unit-water in the Southern Plains contrasts with lower returns per irrigated acre, attributable in part to widespread use of deficit irrigation and relatively low irrigated yields in the region.

Table 2 -- Factors affecting returns to irrigation, by western production region 1/

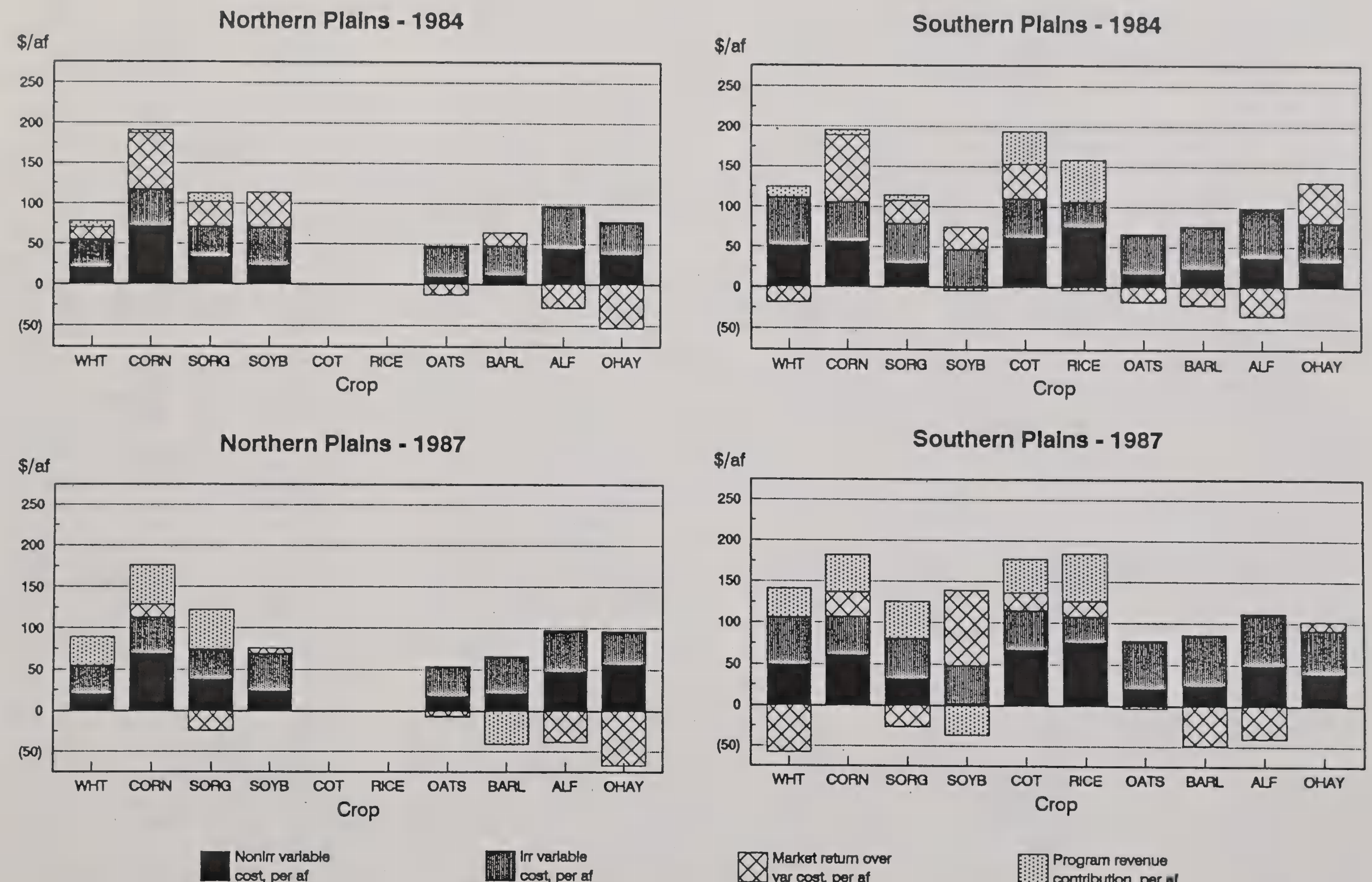
Production region	Major irrigated field crops	Share of regional irrigated field-crop acreage	Water cost per af	Water applied per af	Share of irrigated field-crop acreage in eligible program crops	Share of eligible irrigated program-crop acreage enrolled	Deficiency payment per irrigated program acre	Comments
		Pcnt	$/af	af/ac	--- Pcnt	---	$/ac	
Northern Plains	Corn	61	44	1.1	80	77	88	- Irrigation devoted primarily to corn production
	Soybeans	11						- Heavy reliance on high-cost ground water
	Wheat	9						- Low water use per irrigated acre
	Sorghum	9						- High rates of irrigated program-crop enrollment
	Alfalfa	8						
Southern Plains	Cotton	35	50	1.3	92	75	103	- Irrigation devoted largely to program crops
	Wheat	20						- Heavy reliance on high-cost ground water
	Corn	14						- Low water use per irrigated acre
	Sorghum	14						- High rates of irrigated program-crop enrollment
	Rice	8						
Northern Mountain	Alfalfa	36	27	1.7	38	56	73	- Significant irrigation of nonprogram hay crops
	Other hay	26						- Significant use of low-cost surface water
	Barley	14						- Comparatively high returns to dryland production
	Wheat	11						- Low deficiency payments per irrigated program acre
	Corn	10						
Southern Mountain	Alfalfa	34	30	3.3	49	61	136	- Significant irrigation of nonprogram hay crops
	Cotton	24						- Intensive water use per irrigated acre
	Other hay	16						- Limited dryland production opportunities
	Wheat	14						- High deficiency payments per irrigated program acre
	Barley	5						
Northern Pacific	Alfalfa	37	27	2.0	35	53	91	- Significant irrigation of nonprogram hay crops
	Other hay	28						- Significant use of low-cost surface water
	Wheat	20						- High returns to dryland production
	Corn	7						- Low rates of irrigated program-crop enrollment
	Barley	7						
Southern Pacific	Cotton	34	26	3.2	67	52	191	- Significant use of low-cost surface water
	Alfalfa	24						- Intensive water use per irrigated acre
	Wheat	13						- Low rates of irrigated program-crop enrollment
	Rice	11						- High deficiency payments per irrigated program acre
	Corn	7						

1/ Values are acreage-weighted over the 1984 and 1987 production years.

FIGURE 3

Average cost and return per unit-water in irrigated field-crop production

Northern Plains and Southern Plains regions



Northern Mountain. Commodity programs had a lesser impact on returns to irrigation in the Northern Mountain region, although program revenue contributions accounted for a substantial share of net positive returns per unit-water. Returns to irrigation were moderately low in 1984, as the effects of favorable market conditions and low water cost were offset by lower-valued irrigated crops, relatively high returns to dryland production, and limited commodity program supports. Market revenues accounted for nearly all returns to water. Program contributions of just $2/af (3 percent) reflect small acreages in eligible program crops, low payment and enrollment rates for irrigated program production, and relatively high dryland enrollment.[14] In 1987, returns to irrigation fell with reduced market prices for small grains and favorable dryland yields. Program contributions increased to $8/af (13 percent) with expanded payments and enrollment in irrigated small-grain production (fig. 4).

Southern Mountain. Commodity programs had a moderate impact on returns to irrigation in the Southern Mountain region. Program revenue contributions of $9/af (8 percent) in 1984 were attributable largely to high deficiency payments and enrollment under the cotton program. Total returns to irrigation were relatively low, as intensive water applications lessened the effect of strong irrigated yields and limited dryland production alternatives. In 1987, favorable cotton price and yields prevented the decline in market revenues observed in major grain-producing regions. Program contributions increased slightly to $12/af (11 percent) as expanded irrigated enrollment offset a reduction in cotton deficiency payments. Lower regional returns per unit-water contrasts with high crop returns per irrigated acre (app. table 6).

Northern Pacific. Commodity programs had a lesser impact on returns to irrigation in the Northern Pacific, although commodity payments accounted for a substantial share of net positive returns per unit-water. Returns to irrigation in 1984 were lowest among western regions due to extensive acreage in lower-valued field crops, the relative profitability of dryland production, and limited program supports. Net program contributions of just $1/af (1 percent) reflect limited eligible program acreage, low program payments and enrollment for irrigated land, and relatively high dryland enrollment. In 1987, returns to irrigation declined with reduced market prices across major irrigated crops, despite dry conditions over much of the region. Program contributions rose to $6/af (9 percent) with higher payment and enrollment rates for irrigated small grains (fig. 5). Low returns per unit-water contrast with higher crop returns per irrigated acre (app. table 6).

Southern Pacific. Commodity programs had a moderately high impact on returns to irrigation in the Southern Pacific region. Returns per unit-water were relatively strong in 1984, as the combined effect of high-valued field crops, high irrigated yields, large deficiency payments, and low water costs offset intensive water use per irrigated acre. Commodity programs contributed $12/af (10 percent), despite reduced enrollment among program commodities (other than rice). In 1987, program contributions rose to $21/af (14 percent) with expanded deficiency payments and enrollment. Meanwhile, market-based returns increased - in contrast with major grain-producing areas - due to favorable prices for cotton and rice, generally strong irrigated yields, and very dry conditions across much of the region. Combined returns to irrigation of $64/af were highest among western regions.

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[14] In the Northern Mountain and Northern Pacific regions, lower irrigated enrollment rates contrast with high dryland enrollment. As returns to irrigation are calculated net of program revenues under dryland cropping alternatives, high dryland enrollment reduces reported program revenue contributions per unit-water applied.

FIGURE 4

Average cost and return per unit-water in irrigated field-crop production

Northern Mountain and Southern Mountain regions

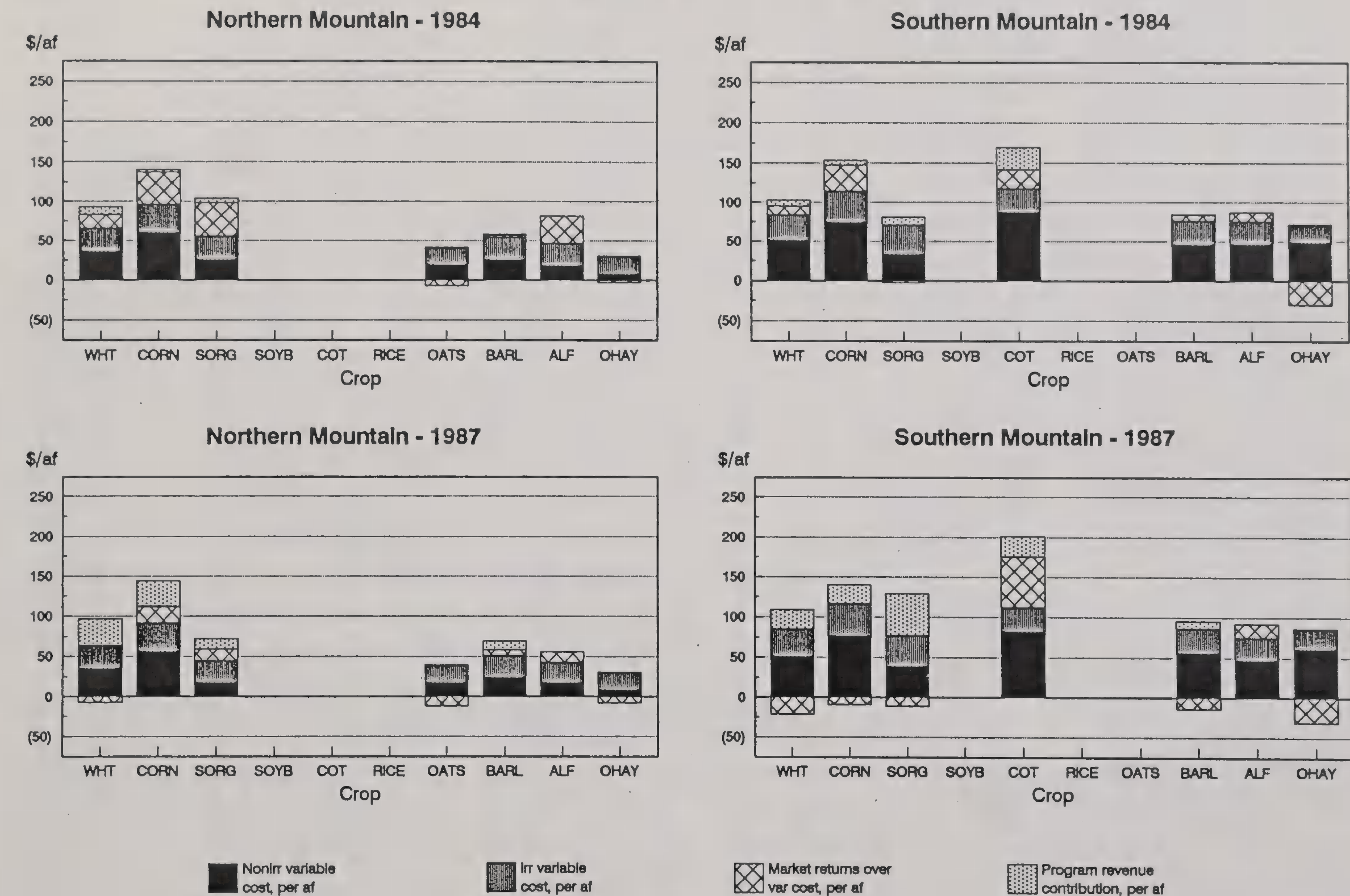
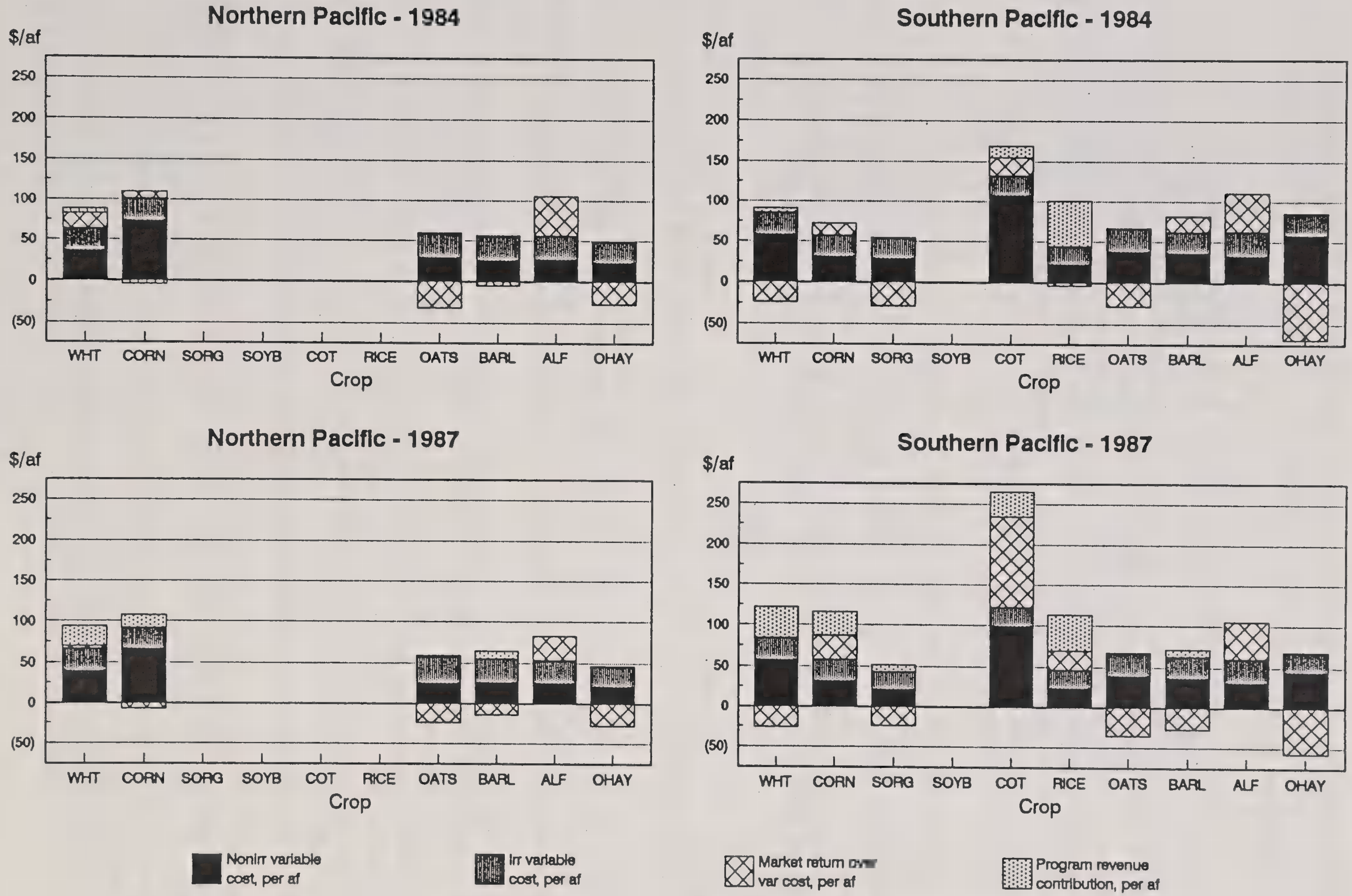


FIGURE 5

Average cost and return per unit-water in irrigated field-crop production

Northern Pacific and Southern Pacific regions



Returns to Irrigation by Major Field Crop

The following discussion assesses the relative importance of commodity program revenue contributions, by major field crop. Primary factors underlying crop variation in returns to irrigation are highlighted in table 3.

Wheat. Wheat program supports had a relatively modest effect on returns to irrigation, although program payments comprised an important share of net returns to irrigated wheat production. Lower returns per unit-water in 1984 reflect reduced market-based revenues per irrigated wheat acre and the relative profitability of dryland wheat in major producing areas. Program revenues contributed $9/af (10 percent) in irrigated wheat production. In 1987, substantially higher wheat program supports offset a decline in market returns. Program contributions of $33/af (37 percent) reflect increased deficiency payments, reduced opportunity costs of wheat set-aside, and expanded program enrollment. Under less favorable market conditions in 1987, positive returns to irrigation were generally dependent on support payments under the wheat program (fig. 6).

Corn. The effect of the feed grain program on returns to irrigation varied significantly with market conditions. In 1984, returns to irrigation for corn were highest among field crops due to exceptionally favorable corn market prices. Program revenues contributed just $4/af (2 percent). Returns per unit-water remained strong in 1987 as low corn prices were offset by higher irrigated yields, declining market returns to dryland cropping alternatives, and increased program supports. Large program contributions of $44/af (26 percent) reflect higher deficiency payments, reduced opportunity costs of corn set-aside, and near-total enrollment of irrigated corn acreage.

Sorghum. The feed grain program had a varying impact on returns to irrigation for sorghum. High returns to irrigation in 1984 reflect favorable sorghum market conditions. Program revenues contributed $8/af (8 percent). In 1987, program contributions rose to $45/af (46 percent) with higher deficiency payments, reduced opportunity costs of sorghum set-aside, and expanded program enrollment. However, total returns per unit-water declined due to reduced sorghum prices and strong dryland-sorghum yields across the Plains States. As with wheat, commodity program supports were needed to achieve positive returns to irrigation in sorghum production (fig. 7).

Cotton. The cotton program had a significant impact on returns to irrigation in each of the study years. Favorable market conditions and program supports in 1984 resulted in strong returns per unit-water applied in cotton production. Program revenue contributions of $28/af (16 percent) reflect high deficiency payments and enrollment for irrigated cotton. In 1987, market-based returns expanded with high cotton prices, strong irrigated-cotton yields, and reduced returns to dryland cropping alternatives. At the same time, program contributions rose to $35/af (17 percent) as increased cotton enrollment offset lower deficiency payments and higher opportunity costs of set-aside. Combined returns to irrigation of $96/af were highest among western field crops.

Rice. The rice program had a significant impact on returns to irrigation. In 1984, program contributions of $54/af (43 percent) were largest among western field crops due to exceptionally high deficiency payments and program enrollment. Positive returns to irrigation for rice were largely dependent on program supports. Limited market-based returns reflect high production costs and intensive water use in rice production, and favorable market conditions for dryland crop alternatives. Returns to irrigation increased in 1987 with improved rice yields and sharply reduced market returns for dryland cropping alternatives. Program contributions slipped to $49/af (34 percent) as higher

Table 3 -- Factors affecting returns to irrigation, by major field crop 1/

Irrigated crop	Major irrigated production regions	Regional irrigated acreage as a share of irrigated westwide	Water cost per af	Water applied per acre	Share of irrigated acreage enrolled in commodity programs	Deficiency payment per irrigated program acre	Comments
		Pcnt	$/af	af/ac	Pcnt	$/ac	
Wheat	N. Mountain	26	37	1.4	0.63	87	- Wide distribution of irrigated wheat production areas
	S. Plains	25					- Lower rates of irrigated program enrollment
	N. Plains	18					- Comparatively high returns to dryland production
Corn	N. Plains	73	43	1.4	0.75	89	- Accounts for 25% of irrigated field-crop acreage in the West
	N. Mountain	11					- Production concentrated in the N. Plains; heavy use of ground water
	S. Plains	9					- Higher deficiency payments and irrigated program enrollment
Sorghum	N. Plains	47	42	1.2	0.64	68	- Irrigated production concentrated in the Plains
	S. Plains	42					- Lower water use per acre; heavy use of high-cost ground water
	N. Mountain	4					- Lower deficiency payments per irrigated program acre
Cotton	S. Plains	48	36	2.2	0.69	175	- Western cotton production across the arid southern-tier regions
	S. Mountain	13					- High water use per irrigated acre
	S. Pacific	39					- High deficiency payments per irrigated program acre
Rice	S. Pacific	55	26	4.4	0.91	261	- Western production limited to central California and Texas Gulf coast
	S. Plains	45					- Intensive water use per acre; heavy use of low-cost surface water
							- High deficiency payments and irrigated program enrollment
Barley	N. Mountain	69	29	1.6	0.34	38	- Irrigated production concentrated in the N. Mountain region
	S. Pacific	12					- Heavy reliance on low-cost surface water
	N. Pacific	9					- Low deficiency payments and irrigated program enrollment
Oats	N. Mountain	66	27	1.4	0.16	7	- Irrigated production concentrated in the N. Mountain region
	N. Plains	11					- Heavy reliance on low-cost surface water
	N. Pacific	10					- Low deficiency payments and irrigated program enrollment
Soybeans	N. Plains	94	47	0.9	--	--	- Irrigated production concentrated in the N. Plains
	S. Plains	6					- Heavy use of high-cost ground water
							- Low water use per irrigated acre
Hay-Alf	N. Mountain	48	31	2.3	--	--	- Wide distribution of alfalfa production areas
	S. Pacific	16					- Accounts for 25% of irrigated field-crop acreage in the West
	N. Pacific	12					- High water use per irrigated acre
Hay-Other	N. Mountain	62	25	1.7	--	--	- Irrigated production concentrated in the N. Mountain region
	N. Pacific	18					- Heavy reliance on low-cost surface water
	S. Mountain	8					

1/ Values are acreage-weighted over the 1984 and 1987 production years.

FIGURE 6

Average cost and return per unit-water in irrigated field-crop production

Wheat and Corn

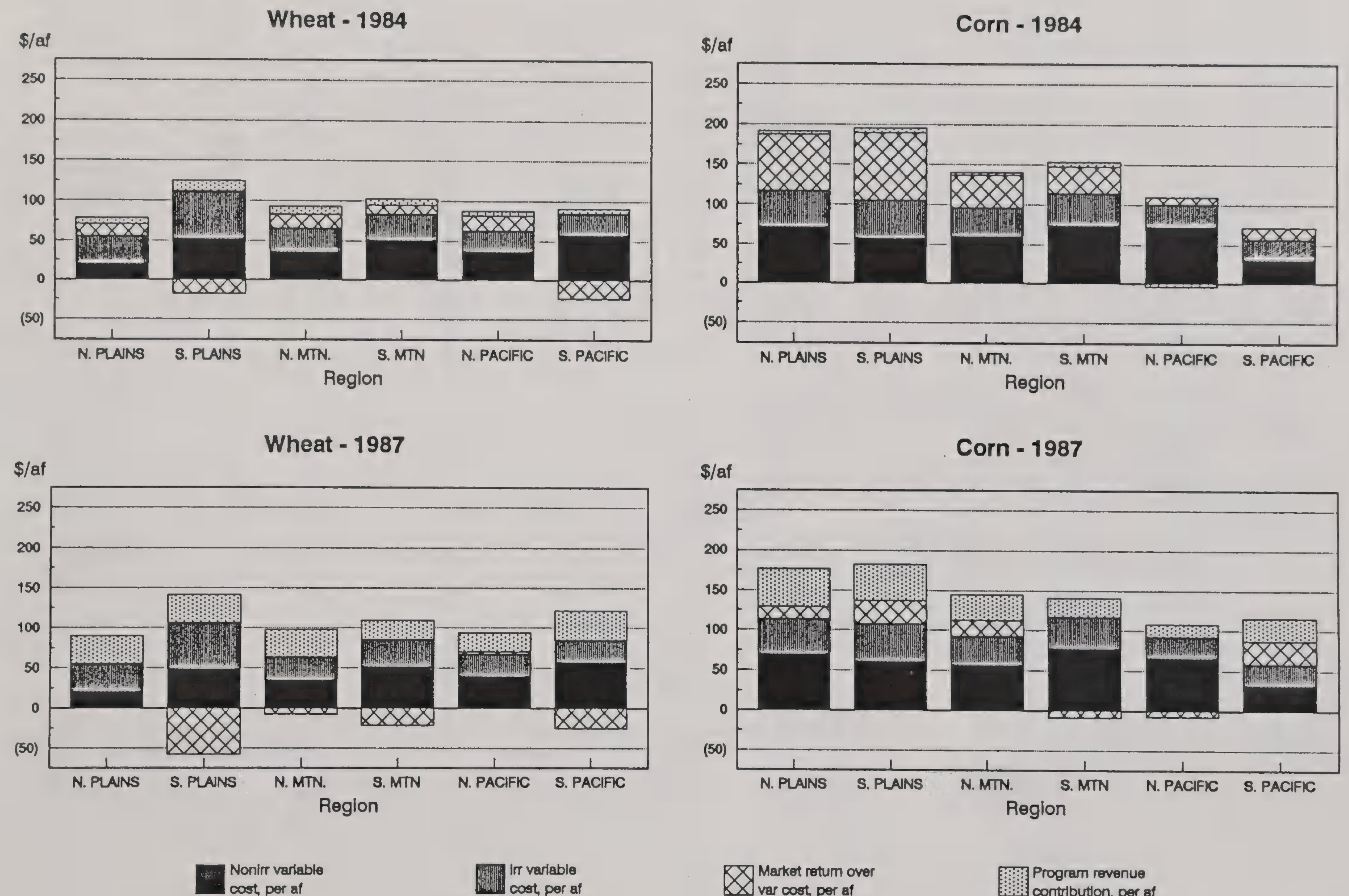
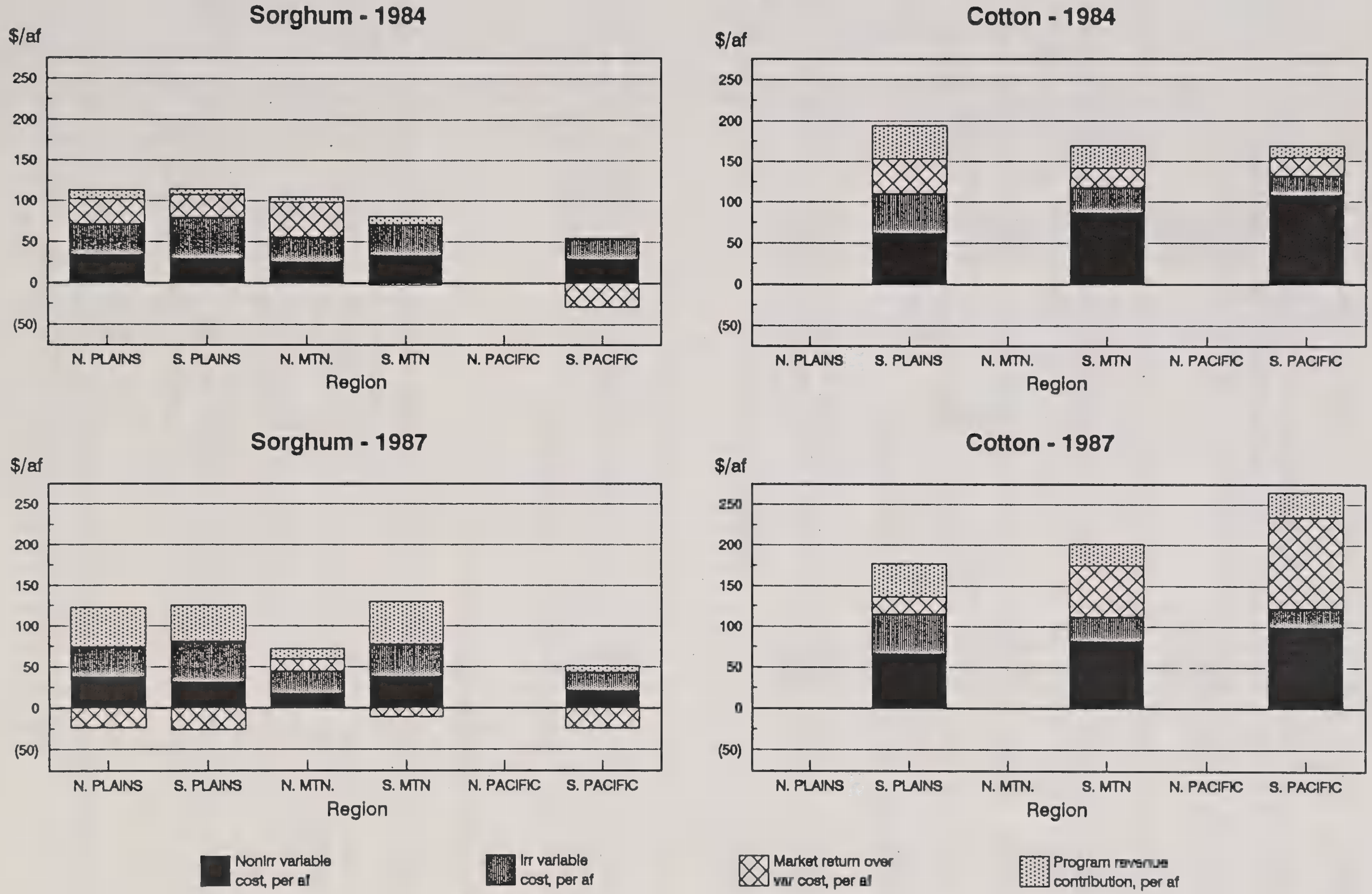


FIGURE 7

Average cost and return per unit-water in irrigated field-crop production

Sorghum and Cotton



opportunity costs of rice set-aside offset an increase in program payments and enrollment (fig. 8).

Barley. The feed grain program had a lesser impact on returns to irrigation for barley. Low returns in 1984 reflect limited market-based returns and program contributions per irrigated barley acre, and relatively high returns to dryland barley production. Program revenues contributed just $1/af (2 percent) due to low deficiency payments and enrollment for irrigated barley. Returns to irrigation increased in 1987 as program contributions of $9/af (13 percent) offset the decline in market revenues per unit-water.

Oats. The feed grain program had a minimal effect on returns to irrigation in oat production. Limited program contributions reflect lower deficiency payments and enrollment for irrigated oats and relatively high enrollment of dryland oats. Negative market returns per unit-water indicate low profitability of irrigated oats relative to dryland production on a westwide basis (fig. 9).

Soybeans. Federal commodity programs had little direct impact on returns to irrigation in soybean production, as market prices generally exceeded the loan rate for soybeans in each of the study years. High returns to irrigation in 1984 reflect favorable market prices and lower production costs for irrigated soybeans. Reduced returns in 1987 were attributable primarily to increased dryland soybean yields across the Northern and Southern Plains.

Alfalfa hay. Commodity programs had little direct effect on returns to irrigation in alfalfa hay production, since alfalfa does not qualify for deficiency payments or loan supports.[15] While returns per irrigated alfalfa acre were fairly strong, intensive irrigation applications limited returns per unit of water applied. Returns to irrigation were relatively high in 1984; returns declined with reduced alfalfa prices in 1987 (fig. 10).

Other hay. Commodity programs had little direct effect on returns to irrigation in nonprogram other-hay production. Market returns per unit-water were lowest among field crops in each of the study years, indicating low profitability of irrigated hay production relative to dryland hay on a westwide basis. However, reported returns do not reflect the benefit of irrigation in ensuring adequate hay supplies for livestock enterprises.

Returns to Irrigation Through the 1990's

Federal commodity programs are likely to be modified under the 1995 farm bill. Various proposals under consideration call for reduced budgetary outlays for deficiency and loan payments, greater reliance on market signals through lower support levels and increased planting flexibility, and expanded environmental provisions. Meanwhile, debate continues over ratification of negotiated terms under the Uruguay Round of the General Agreement on Tariffs and Trade (GATT). The GATT agreement seeks to reduce agricultural trade barriers through reductions in subsidies, tariffs, and import quotas for farm commodities. Prospects of lower farm supports and higher commodity prices under a successful GATT trade agreement, and the potential for further legislation to achieve targeted reductions in Federal expenditures, suggest a continuing decline in commodity program

[15] As alfalfa is a primary feed component for western dairy production, returns to irrigation in alfalfa production are indirectly supported through the Federal Dairy Program (not considered here).

FIGURE

Average cost and return per unit-water in irrigated field-crop production

Rice and Barley

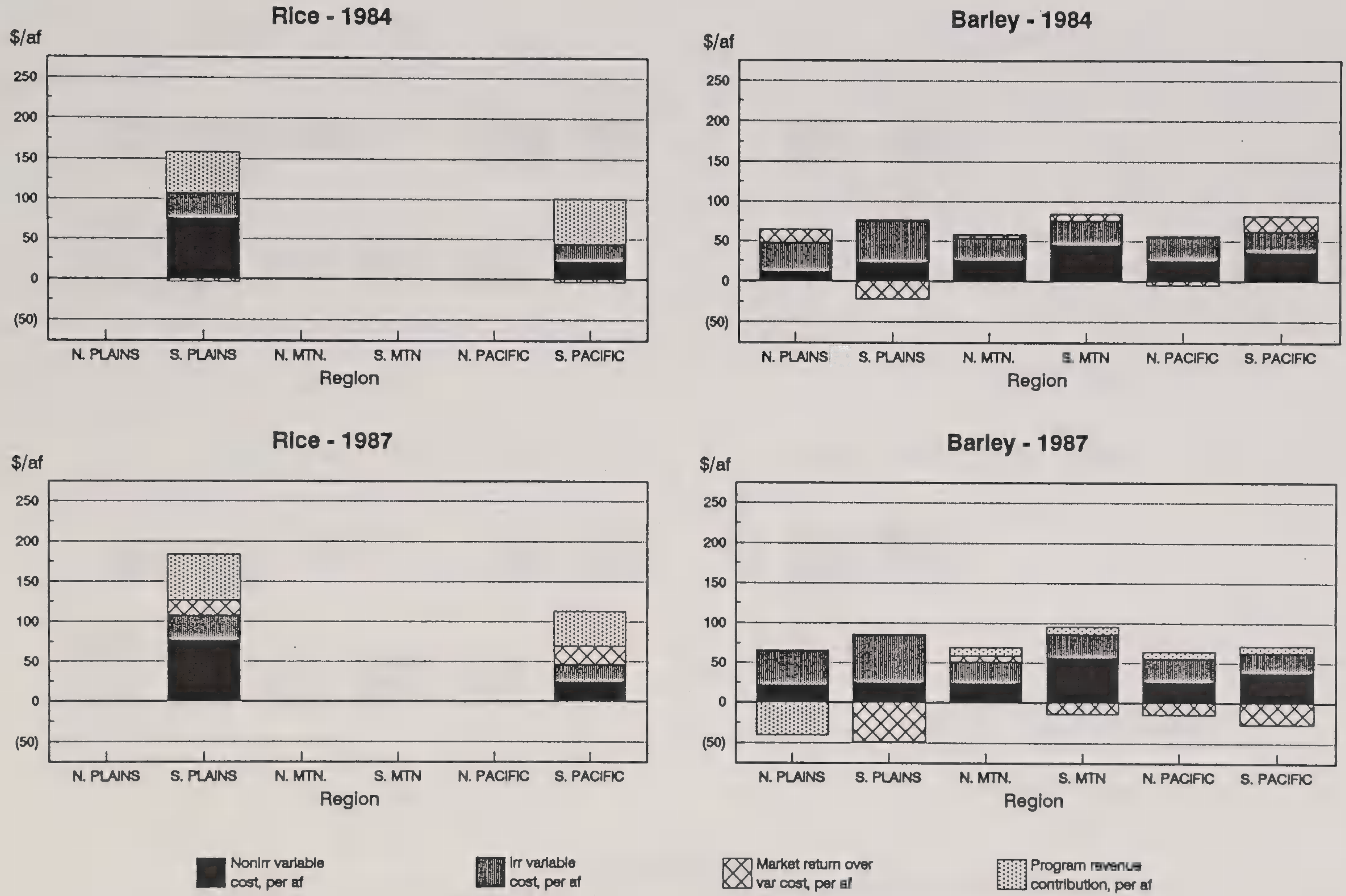


FIGURE 9

Average cost and return per unit-water in irrigated field-crop production

Oats and Soybeans

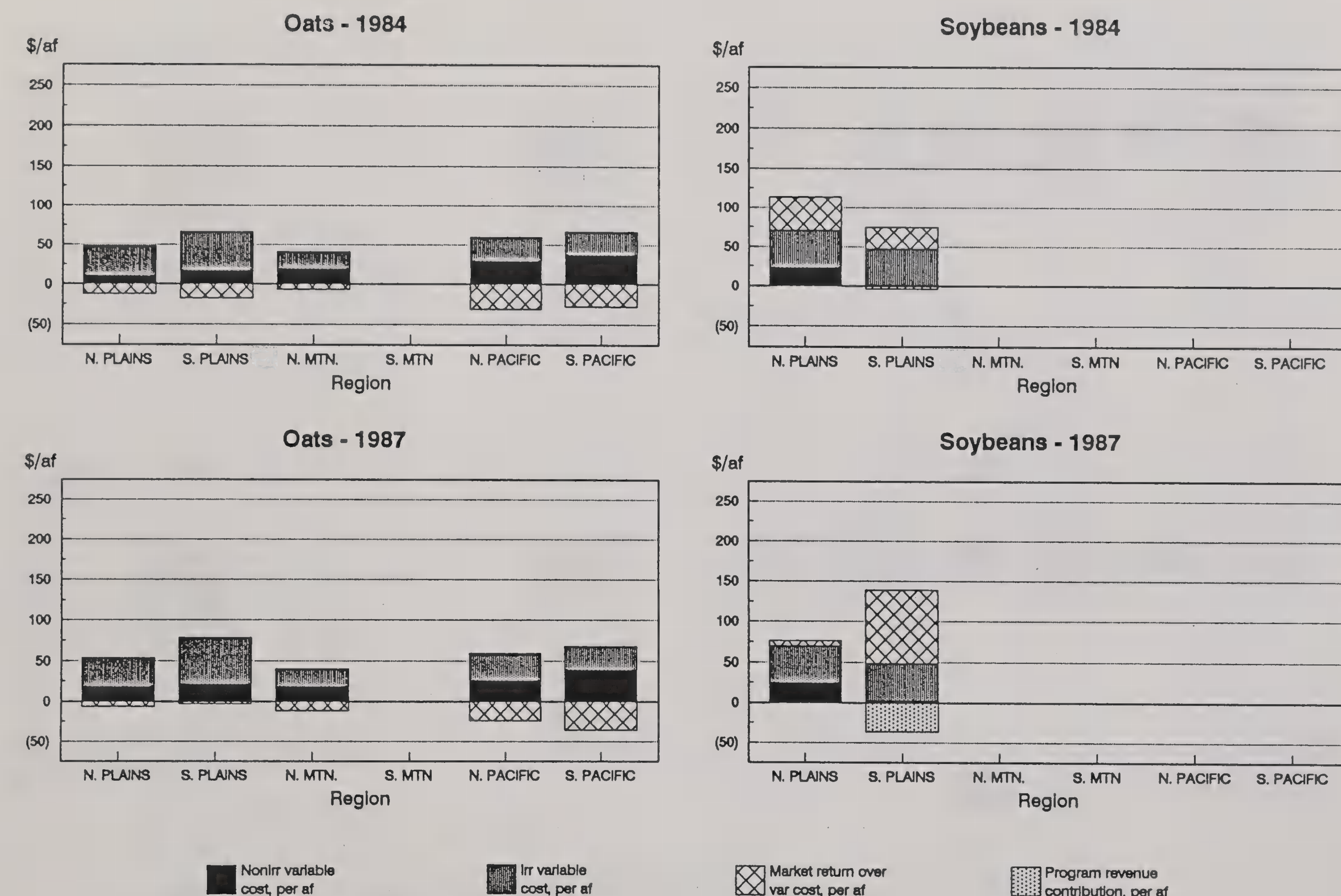
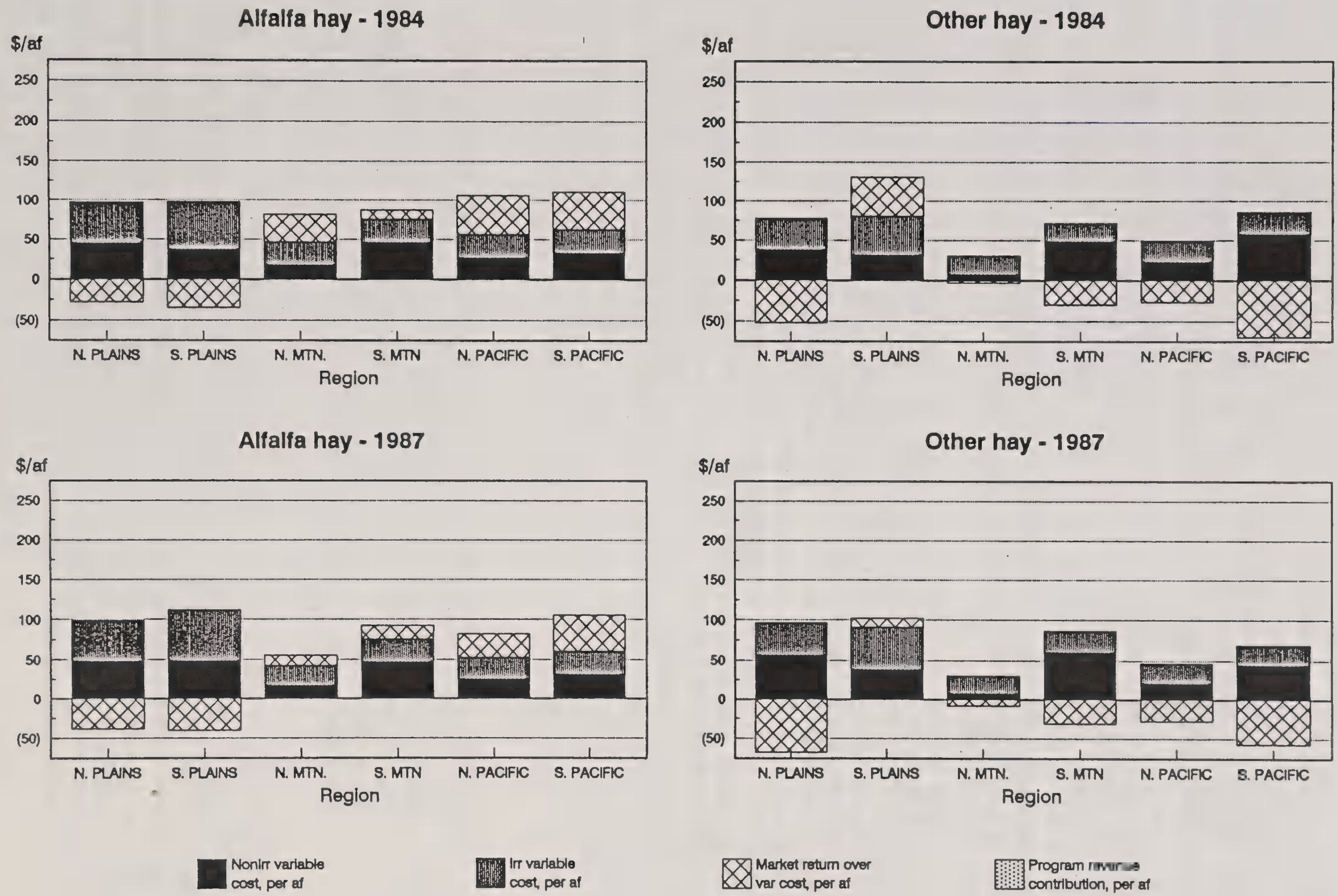


FIGURE 10

Average cost and return per unit-water in irrigated field-crop production
Alfalfa and Other Hay



payments through the 1990's.

Reduced commodity program supports may affect the level and variability of returns to irrigation in western field-crop production. The direction and magnitude of the effect will depend on crop market conditions. In general, deficiency payments per unit-water rise (fall) as market prices fall (rise). Reduced support levels can be expected, however, to restrict program revenue contributions and strengthen market share of total revenue for a given market price.

The prospect of reduced commodity supports is compounded by potential increases in the cost of irrigation. Higher energy prices would raise the real cost of irrigation pumping and system pressurization. Ground-water pumping costs may further increase due to declining aquifer levels - most notably in the Southern Plains, Mountain, and Southern Pacific regions. Political pressures are mounting to raise the price of purchased surface water provided by Federal water projects[16], while pumping and drainage surcharges have been proposed to control ground-water overdraft and water-quality degradation.

Regional effects of commodity policy reform on returns to irrigation will depend on regional cropping patterns, market conditions for crops produced, the irrigated sector's reliance on commodity programs, and local adjustments in irrigation water cost and supply. Reduced commodity supports may have a substantial impact on returns to irrigation in the Northern and Southern Plains, where irrigated production of program crops is significant and program participation is historically high. Impacts may also be significant in the Southern Pacific and Southern Mountain regions where heavily supported irrigated cotton and rice are concentrated. Reduced supports are likely to have lesser aggregate impacts in the Northern Mountain and Northern Pacific regions, due to large acreages in nonprogram hay crops, lower deficiency payments for irrigated small grain production, and historically low levels of program enrollment. However, local impacts may be important in these regions as small program revenue contributions account for a significant share of net returns to irrigated production.

[16] The U.S. Bureau of Reclamation supplies water to roughly 25 percent of western irrigated acreage. Much of this water is provided at "below-cost" water prices, although subsidies vary widely due to differences in capital investments and costs recovered (Moore and McGuckin, 1988). The Reclamation Projects Authorization and Adjustment Act of 1992 (P.L. 102-575) provides for renegotiation of contract prices for Federal project water in central California.

Opportunities for Water Conservation

The U.S. Department of Agriculture identifies irrigation water conservation as one of the primary agricultural policy objectives for the 1990's (USDA, 1989). Improved irrigation management can help to offset the effect of rising water costs and restricted water supplies on producer income. At the regional level, conservation of irrigation water supplies is considered essential to meeting future water demands for agricultural, urban, and environmental uses. Water conservation may also enhance surface- and ground-water quality, since irrigation drainage contributes to pollutant loadings of collecting water bodies. USDA supports water conservation in irrigated agriculture through local demonstration projects, onfarm technical assistance, and cost-sharing for improved irrigation systems.

Commodity policy reform - motivated primarily by budget-control and competitiveness considerations - may also serve to lessen agricultural water demand. Lower deficiency payment rates, fixed payment yields, and reduced payment acres restrict revenue contributions under the commodity programs, thus reducing water-use incentives in irrigated program production. Reduced loan rates that lower market-clearing prices for program crops may further lessen water-use incentives for participating and nonparticipating irrigators. Meanwhile, fixed payment yields and expanded planting flexibility on base acreage severs (at least temporarily) the link between commodity program benefits and applied water. As a result, participating irrigators can limit their water use with only minimal reductions in program revenues.

Adjustments in Water Use

The effect of commodity policy reform on water demand will depend on the nature and extent of production adjustments in irrigated agriculture. Water conserved through adjustments in commodity programs represents a *potential* source of water supply for non-agricultural uses, particularly during water-short years. Net water savings may be tempered, however, by the offsetting effects of reduced program participation, lower ARP set-aside requirements, declining CRP enrollment, and modified cropping patterns.

Changes in commodity policy will affect total acreage under irrigated production. Reduced commodity supports may slow expansion of irrigated program base on newly developed land. Compliance restrictions further limit irrigation development on environmentally sensitive lands with highly erodible or hydric soils. Conversion of dryland base acreage to high-yielding irrigated production may also be reduced, since deficiency payments are indexed to fixed historic yields. Where irrigation costs are high and natural precipitation is sufficient for crop growth, lower commodity supports may favor dryland production on formerly irrigated acreage.

Total cropland irrigated may also be affected through voluntary, short-term idling of base acreage under the commodity programs. Through the 0/85 provision for wheat and feed grains and 50/85 provision for cotton and rice, producers may devote a portion of "maximum payment acreage" (crop base less ARP set-aside and normal flex) to conserving land uses.[17] In return, producers receive

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[17] Wheat and feed-grain producers may enroll all of their payment acreage under 0/85. Cotton and rice producers must plant at least 50 percent of their maximum payment acreage to cotton or rice under 50/85.

deficiency payments on designated acres in excess of 15 percent of maximum payment acreage, while retaining base eligibility for future program benefits.[18] Under less favorable market conditions, irrigated crop production may generate only a small *net* increase in producer income above partial deficiency payments for idled base acreage.[19] Incentives to idle program base will depend on the level of partial payments for idled acreage, the incremental return to irrigated program production, market returns to eligible nonprogram crops or conserving uses, and producer opportunities for unused water supplies.[20]

Commodity policy reform may induce shifts in cropping patterns, with implications for agricultural water demand. Reduced support levels for program crops and expanded planting flexibility on program base acres are likely to increase the share of irrigated acreage planted to nonprogram field crops.[21] Expanded market returns on flex and 0-50/92 acreage may offset lower program payments per unit of water applied. Changes in production may also induce changes in market prices for some crops.[22] Opportunities for water conservation will depend on whether flexibility provisions and relative crop returns favor less water-intensive crops.[23]

Commodity policy reform measures may also affect applied water per crop acre. Lower program supports and fixed payment yields reduce incentive to maximize production on existing irrigated acres. Producers may choose to deficit-irrigate (apply less water than required to achieve maximum yields) without loss of program benefits. Potential increases in market returns are greatest where irrigation supplies are limiting and water costs are high.

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[18] Partial deficiency payments for idled program base was introduced under the 0/92 and 50/92 provisions of the 1985 farm bill. The 0/85 and 50/85 provisions, in effect since 1994, restrict the share of maximum payment acreage eligible for deficiency payments (from 92 to 85 percent). Producers may continue to qualify for 0/92 and 50/92 in cases where payment acreage is planted to approved crops (e.g., minor oilseeds, industrial crops) or natural weather conditions result in failed crops or prevented planting.

[19] Under 0/85, wheat and feed-grain producers who idle all their eligible payment acreage would forgo 15 percent of deficiency payments per idled payment acre, in addition to market returns on forgone production. Under 50/85, cotton and rice producers would lose 30 percent of deficiency payments per idled payment acre (assuming 50 percent of maximum payment acreage idled), in addition to forgone market returns.

[20] While the 0-50/85 and 0-50/92 provisions do not directly affect costs and revenues per unit-water applied in irrigated production (as reported in table 1), partial deficiency payments for idled acreage lessens the imputed contribution of water and other production inputs to producer income. The effective value of water is reflected in net market returns for irrigated program acres under production, plus the marginal increase in deficiency payments.

[21] Selected nonprogram crops may be planted on "normal flex" acreage (15 percent of base) and "optional flex" acreage (up to 10 percent of base) without affecting program base acreage.

[22] Reductions in irrigated program production are not likely to have a significant impact on prices and competitive position for most commodities. With the exception of rice and cotton, irrigated program production accounts for a limited share of national field-crop production.

[23] Acreage shifts to nonprogram soybeans, comprising the majority of total flex acres planted in 1992, may reduce water demand due to low consumptive requirements in irrigated soybean production. A shift to water-intensive alfalfa hay could result in increased water use.

Finally, commodity policy reform may influence adoption of water-conserving technologies, with potential effects on water demand. Use of improved irrigation systems has been relatively widespread in "water-scarce" areas with higher rates of irrigated program enrollment (for example, the Plains States). The decoupling of program benefits from production reduces incentives to invest in yield-enhancing irrigation technologies that utilize water more efficiently. At the same time, lower guaranteed commodity payments may limit investment capital available to farmers. While policy reform could slow irrigation improvements in some areas, other factors (such as rising water cost, limited water supplies, and water-quality controls) are likely to sustain technology investment through the 1990's.

Federal Water Policy Extensions

Conservation benefits of commodity policy reform may be enhanced through a broader integration of commodity and water policies at the Federal level. Policy measures could be designed that combine commodity program and water conservation objectives.

Conservation policy. One possible approach involves allocation of irrigation technical assistance and cost-share funding based on commodity program considerations, as well as traditional water use and supply factors. As commodity programs are an important determinant of water use, the need for conservation incentives should be evaluated within the context of commodity policy reform and its potential impact on agricultural water demand. Conservation-incentive programs may be more effective where reduced commodity supports and decoupling of program benefits lower the *potential* derived demand for irrigation water.[24] In some cases, reduced supports that induce significant reductions in water demand could lessen the need for conservation-incentive measures. Consideration of commodity program effects is consistent with the recent targeting of limited conservation funding to areas of most critical need.[25]

An alternative, although complementary, strategy links commodity program eligibility to local water use and supply conditions (Just and others, 1991). Under existing legislation, commodity income and price supports are applied nationally whereas the water scarcity problems they contribute to are of varying severity across regions. Program legislation could be modified to discourage excessive agricultural water use in critical water-scarce areas (for example, ground-water overdraft regions or drainage basins with critical instream flow needs for environmental purposes). This could involve expanded compliance provisions for water conservation that tie program benefits to approved irrigation practices or that eliminate program eligibility for newly irrigated lands. Problems may arise in designating targeted regions, identifying approved practices, and monitoring program compliance. Nonetheless, precedent for addressing environmental and resource objectives through Federal commodity programs has been established under the sodbuster and swampbuster provisions of the 1985 and 1990 farm bills.

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[24] Actual adjustments in irrigation water use may depend on financial and technical assistance to alter traditional irrigation practices.

[25] USDA conservation payments are currently targeted to specific land categories (or areas) under the Conservation Reserve Program (CRP), the Water Quality Incentives Program (WQIP), and the Small Watershed Program (P.L. 566).

Reclamation policy. USDA compliance provisions for water conservation could be coordinated with the Bureau of Reclamation (BoR). Under the Reclamation Reform Act of 1982, irrigation districts receiving Federal project water are required to submit a water conservation plan. Plan evaluation criteria are being developed in support of the Central Valley Project Improvement Act (1993) to encourage water-use efficiency within the project service area. The BoR is assessing the eventual use of these criteria to evaluate water conservation plans for Bureau projects throughout the West (Martin and others, 1994).

Much attention has focused on the apparent inconsistency between USDA commodity policies and BoR water supply/pricing policies (Moore and McGuckin, 1988; Wahl, 1989; USGAO, 1991). At issue is the fact that Federal project water at often subsidized (below full-cost) prices may be used to produce surplus crops eligible for Federal price and income supports. Critics have called for elimination of commodity payments for program crop production on lands served by subsidized project water, arguing that an effective "double subsidy" increases government expenditures while encouraging excess irrigation in water-scarce areas. Counterconcerns focus on the uncertain effects of policy reform for aggregate water use and expenditures, the potential costs imposed on farmers and rural economies, and implementation costs for project lands involving multiple water sources and diversified crops.[26]

Water marketing. The development of market mechanisms for transfer of agricultural water supplies is often cited as a means to meet emerging water demands in the West (Frederick, 1987; Wahl, 1989; Moore, 1991). Water markets would encourage the conservation and reallocation of agricultural water by providing farmers compensation for unused water entitlements. The potential for market transfers is significant, since the value of water in irrigation is often substantially less than its opportunity cost in alternative irrigated crops and nonagricultural uses (Gibbons, 1986). Recent sales of water rights in expanding urban areas of Arizona, Nevada, and eastern Colorado have ranged from $50/af to over $200/af in annualized value terms (Shupe and Ass., Inc., 1989).[27] At an estimated average return to irrigation of $33/af in western field-crop production (and still lower marginal returns to applied water), voluntary transfers of irrigation water rights are likely to enhance economic returns to regional water supplies.[28]

Despite significant potential for water marketing, movement of agricultural water supplies remains limited. Legal and institutional barriers at the Federal, State, and local levels have restricted widespread development of operational markets for water. Meanwhile, political concerns have focused on secondary impacts of reduced agricultural activity on local communities. Where market structures are in place, distortions in farm input costs and output returns may discourage water

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[26] A proposed "double-subsidy" provision was debated under the 1991 Omnibus Water Bill (H.R.429); the Reclamation Projects Authorization and Adjustment Act of 1992 (Public Law 102-575) provides for a supplemental charge for water use on surplus program production within the Central Utah Project.

[27] Estimates reflect the annualized value of a permanent transfer of water rights at a discount rate of 5 percent. A permanent water right valued at $2,000 has an annual discounted value of $100/af.

[28] Although transfer values indicate strong demand for water in rapidly growing urban areas, they may not reflect nonagricultural demands generally. In addition, price-inelasticity of water demand in urban uses suggests that transfer prices would decline significantly as the quantity of water transferred increases (Gibbons, 1986; Moore, 1991).

transfers to higher-valued agricultural and nonagricultural uses (Frederick, 1987; Gardner, 1987; Wahl, 1989; Moore, 1991). While efforts to expand water marketing are complex and controversial, recent policy reform under the Central Valley Project Improvement Act (Public Law 102-575) may signal an eventual relaxing of transfer restrictions on Federal water supplies throughout the West.

Commodity policy reform measures are likely to enhance marketing opportunities for western water supplies in the 1990's. With the decoupling of program benefits from production, future deficiency payments are largely unaffected by short-term reductions in irrigation water use. For example, protection of program benefits for cropland idled under the 0-50/92 provisions helped to encourage a temporary transfer of critical water supplies during the extended California drought (Mann and Moore, 1993). Reduced price and income supports through lower target prices and loan rates may provide additional incentive for long-term water transfers to nonagricultural uses. While this study indicates that commodity program revenue contributions to the western irrigated sector are substantial - ranging from \$8/af in 1984 to \$22/af in 1987 - commodity supports alone are probably not high enough to significantly restrict water marketing activity in most areas. Reduced support levels should nonetheless facilitate market transfers of agricultural water supplies once legal and institutional barriers to water marketing are eased.

Conclusion

Federal commodity programs have accounted for a significant share of returns to irrigation in western field-crop production, particularly under less favorable market conditions. Reform measures under the current farm legislation - and prospects for further program adjustments in the coming years - are likely to reduce agriculture's reliance on commodity supports through the 1990's. Opportunities exist for voluntary conservation of irrigation supplies as agriculture adjusts to changing farm commodity programs. Effects on aggregate water demand will depend, in part, on the regional importance of commodity programs to the irrigated crop sector. Water savings are potentially significant where program revenue contributions are historically large, or where lesser contributions account for a substantial share of returns to irrigation. Potential conservation benefits may be enhanced through a broader integration of Federal commodity and water policies that targets conservation to areas of critical need and facilitates water transfers to satisfy those needs.

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Appendix: Study Data, Assumptions and Estimation Procedures

Study Data

Production costs and returns were assembled by study crop for the 17 western States. Sources for acreage, yield, price, and production cost data are outlined below.

Acreage. State-level harvested acres reported by the National Agricultural Statistical Service (NASS), USDA, served as benchmark acreages for the study (USDA, 1984/1987). Acres irrigated in 1984 were drawn primarily from the 1984 Farm and Ranch Irrigation Survey (FRIS), conducted by the Census Bureau, U.S. Dept. of Commerce (USDC), in cooperation with USDA (USDC, 1986).[29] Acres irrigated in 1987 were based on unpublished 1987 NASS estimates, and supplemented with data from FRIS and the Census of Agriculture (USDC, 1989). Appendix table 1 reports harvested acres by region and crop, irrigated and dryland, for 1984 and 1987.

Representative dryland production alternatives were specified for each irrigated crop by State (app. table 2). Selection of dryland alternatives was based on county-level cropping patterns for irrigated and dryland production from the 1987 Census of Agriculture (USDC, 1989).

Acreage set-aside requirements, used to calculate opportunity cost adjustments for ARP-idled lands, reflect program provisions by crop for the 1984 and 1987 production years (USDA, 1989). Harvested base acreage in programs, used to calculate enrollment rates across total harvested acres by crop and State for 1984 and 1987, was obtained through the Agricultural Stabilization and Conservation Service (ASCS). As acreage estimates for irrigated enrollment were available for 1987 only, irrigated enrollment as a percentage of total enrollment by crop and State is assumed to be equivalent across study years (app. table 3).[30]

Planted-harvested acreage ratios were used to adjust deficiency payments (per planted acre) to a per-harvested-acre basis. Planted-harvested ratios were calculated based on NASS harvested and planted acres by crop and State for 1984 and 1987. Ratios were further adjusted for irrigated and dryland production, based on planted-harvested differentials reported in 1982 USDA crop enterprise budgets (USDA, 1985).

Crop yield. State-level crop yields for irrigated and dryland production draw on NASS estimates for 1984 and 1987, where available, and 1984 FRIS survey data. Crop yields are assumed equal across participating and non-participating acres. Program yields qualifying for deficiency payments in 1984

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[29] The 1984 FRIS draws on a sample of western irrigated farms surveyed under the 1982 Agricultural Census. Survey responses are statistically significant at the State level.

[30] An historical comparison of national acreage diversions and total irrigated acreage suggests that irrigated/dryland enrollment ratios held fairly constant through the 1980's. Adjustments in national irrigated acreage averaged about 10 percent of the annual adjustment in diverted areas (Quinby and Hostetler, 1990).

and 1987 were based on ASCS program yields by State, irrigated and dryland, for 1987.[31] In computing opportunity costs of set-aside, it is assumed that the least productive acreage is idled and that potential yields on this acreage are 80 percent of NASS-reported yields (Dvoskin, 1989).

Where climate varies significantly within a State, dryland yields in more arid irrigated-production areas may be substantially lower than state-average dryland yields. For selected irrigated crops, state-average yields for dryland crop alternatives were reduced by 10 percent in order to calculate the difference in per-acre returns across irrigated and dryland production (see app. table 2). Yield adjustments reflect judgment estimates of the author, based on consumptive moisture requirements for substate areas where irrigation is concentrated (USDA-SCS, 1976; Heimes and Luckey, 1982).

Crop prices. Market prices for program crops are based on NASS season-average prices at the State level for 1984 and 1987. Market prices for alfalfa and other hay are based on NASS state-level monthly prices for September. Target prices, loan rates, and deficiency payment rates reflect ASCS rate provisions for program crops in effect for 1984 and 1987 (USDA, 1989). See appendix table 4 for average market prices and commodity program support levels, 1982-93.

Water application rates. Water application rates for 1984 are based on survey data by crop and State from the 1984 FRIS. Water application rates for the 1987 production year are based on ERS estimates for nonsurvey years that account for changes in both seasonal precipitation and improvements in water-use efficiency (app. table 5) (Quinby, 1994). Application rates by crop are assumed equivalent across program and nonprogram acres.[32]

Production costs. Water costs by crop and State for 1984 are based on survey data from the 1984 FRIS. Water costs for the 1987 production year are based on 1984 cost estimates, adjusted to reflect differences in water application rates and price-indexed to 1987. Variable water costs reflect an acreage-weighted average of energy costs for pumping and pressurization (ground and surface water) plus costs of purchased surface water.

Nonwater costs involving chemical, energy, labor, and machine inputs are based on state-level production data in the Irrigation Production Data System, price-indexed to 1984 and 1987 (Schaible and others, 1989). Conservation compliance costs for ARP set-aside lands (e.g., cover establishment, weed control) reflect ASCS survey data and published budget estimates (Krenz and Garst, 1985). Forgone production costs on idled acreage are assumed equivalent to actual costs on harvested acres.

Crop returns. Market and program revenues over variable production costs per acre were calculated by major field crop for irrigated and dryland production at the State level. Returns are reported by western production region (all field crops) and by field crop westwide (app. table 6 and app. fig. 1).

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[31] Prior to 1985, program yields were revised annually by farm based on a moving average of harvested yields over the preceding 5-year period. The 1985 farm bill fixed the level of program yields for subsequent years at 1984 levels. Deficiency payments are calculated based on program yields over eligible payment acreage, irrespective of actual harvested yield.

[32] Irrigators with fixed water entitlements (or pump capacity limits) may elect to apply water more intensively over a smaller planted acreage under the commodity programs. The resulting change in application rates is not considered to be significant area-wide.

Study Assumptions

Estimated returns to irrigation reported in this study reflect underlying data, definitions, and analytic methods. Key assumptions are addressed briefly below.

- The static nature of the analysis precludes a full assessment of potential production adjustments due to Federal crop commodity programs. The study focuses on returns to irrigation under observed market conditions, without attempting to quantify dynamic shifts in crop prices, cropping patterns, irrigated acres, and water use attributable to commodity programs. If one accounted for reduced market prices in the absence of set-aside requirements, program effects on returns per unit-water would likely be greater than those presented in this report.[33]

- Returns to irrigation presented in this report represent season-average returns. Implicit in the "average return" measure is the assumption that all nonwater inputs are compensated at their marginal productivity, and returns above cost are attributable exclusively to water. "Marginal return", or return to the marginal increment of water applied, is often lower than average return due to diminishing marginal yields over an observed range of water applications. While average return to irrigation reflects total water applied over the crop season, a producer's willingness to reduce applied water more accurately reflects the marginal value of water. Commodity program revenue contributions are more readily expressed as a share of average returns to irrigation, given the quasi-fixed nature of deficiency payments per acre.

- Reliance on state-aggregate budget data masks considerable variation in production conditions within State boundaries. Sources of variation include topography, soil, climate, water availability, farm size, tillage practices, cropping alternatives, and irrigation technology. Each of these factors may affect production costs, water use and productivity, with varying impacts on returns to irrigation at the substate level.

- Returns to irrigation presented here reflect prevailing conditions during the 1984 and 1987 study years. Returns will vary annually due to changes in commodity prices, program provisions, weather patterns, surface-water availability, and other factors. Longrun adjustments in water price, water supply, and irrigation technology will further influence returns to irrigation over time. Intraseasonal adjustments in crop moisture needs, precipitation, and other factors affecting the productivity of applied water over the cropping season are not addressed.

- Estimated returns to irrigation reflect a shortrun time frame, based on single-season revenues over variable production costs. Returns are likely to be lower in a longrun, multiyear analysis in which all fixed production costs are fully accounted for. The magnitude of fixed-cost adjustments will differ across crops and regions due to variation in irrigation systems, machinery complements, and other capital assets.

- Returns to irrigation are calculated based on quantity of water applied at the field level. However, only a portion of applied water is actually consumed in crop production. Irrigation drainage to streams and underlying aquifers may be available for reuse, thereby increasing potential returns

[33] Market price effects are likely to be minor for small grain and forage crops, as irrigated acreage enrolled in programs accounts for a relatively small share of total U.S. production.

per unit of water supply in the basin. On the other hand, water conveyance losses from diversion point to field gate are not considered, although they may be significant in some cases (Solley and others, 1993). Accounting for net conveyance loss reduces effective returns to irrigation water.

- o Returns to irrigation are calculated based on farmlevel producer returns per harvested acre, net of forgone returns on set-aside acres. Estimates do not reflect irrigation-induced environmental costs due to ground-water overdraft, instream flow reductions, and irrigation drainage pollution. Inclusion of offsite and intertemporal social costs attributable to irrigation would lessen returns reported here.

- o Return estimates do not reflect the effect of base acreage idling provisions after 1985 or cropping flexibility provisions after 1990. While partial deficiency payments for idled program acreage may restrict total commodity program expenditures, reduced water use due to idling of irrigated cropland could potentially increase outlays per unit-water applied. Market-based returns to irrigation would likely increase with expanded production of nonprogram crops under the 0-50/92 and flex provisions. The analysis does not consider producer payment limitations which may restrict aggregate farm program contributions to the irrigated crop sector.

- o Various other USDA program provisions affecting water use and returns to irrigation are not considered. These include payments for voluntary acreage reductions (Paid-Land-Diversion, CRP), export-enhancement payments, disaster payments, dairy program supports, cost-sharing for land improvements, technical assistance, and extension activities. Below-cost pricing for Federal-project water and energy is not examined, although price subsidies for irrigated production may be significant in some regions. The effect of income tax provisions is also not considered. Returns to irrigation would likely be lower than those reported here in the absence of programs designed to support farm income.

- o Return estimates reported here are "ex-post" since they reflect current-year market prices. Program participation decisions (and to a lesser extent, irrigation decisions) are made "ex-ante" based on expected market prices. While reported estimates reflect actual returns to irrigation for the production year, they may vary from preseason expected returns which drive production decisions, particularly where actual and expected market prices differ significantly.

- o Returns to irrigation are based on an analysis of primary field crops only. Irrigated acreage in study crops accounts for roughly 85 percent of total irrigated acreage in the West. Returns to irrigation in nonprogram vegetable and orchard production are not considered, although these crops account for substantial water use in some areas. Inclusion of higher-valued specialty crops would increase reported market returns to irrigation in major producing regions.

- o Crop returns to irrigation do not reflect the effect of cross-commodity effects in a whole-farm context. Under a cotton-alfalfa rotation, for example, the value of applied water in nitrogen-fixing alfalfa production is partly reflected in increased returns to cotton. In the case of forage crops such as hay and oats, returns to irrigation may be partly captured in the value of a livestock enterprise. Actual returns to irrigation may differ from those reported here, depending on interactions among farm enterprises.

- o Estimated returns to irrigation do not consider the effect of irrigation and commodity programs on producer risk. By ensuring crop-water needs during periods of drought, irrigation reduces the

likelihood of revenue loss due to yield decline and crop failure. Similarly, program enrollment lessens producer income variation through guaranteed crop loans and income supports. Accounting for risk adjustments would increase both the total return per unit-water and the contribution of program revenues reported here.

Calculation of Returns to Irrigation by Crop and State

The following equations summarize return calculations used in the study. Equations 1 and 2 represent per-acre crop returns for irrigated and dryland production, based on market revenues plus commodity program contributions, net variable production costs. Program contributions include deficiency payment and loan supports, less compliance costs and forgone benefits on set-aside acreage, adjusted for planted/harvested differentials, and acreage-weighted across program and nonprogram production. Equation 3 represents shortrun, average returns to irrigation (net of dryland returns) per unit-water applied.

(1) Returns per irrigated acre:

$$
\begin{aligned}
NRAC_{\underset{I}{cs}} = {} & (1-R_{\underset{I}{cs}}) \, [Y_{\underset{I}{cs}} (P_{cs}) - CV_{\underset{I}{cs}} - CI_{\underset{I}{cs}}] \\
& + R_{\underset{I}{cs}} \, [Y_{\underset{I}{cs}} (P_{cs} + LS_{cs}) + YP_{\underset{I}{cs}} (DP_c) \, (1/X_{\underset{I}{cs}}) - CV_{\underset{I}{cs}} - CI_{\underset{I}{cs}} \\
& - (Y_{\underset{I}{cs}} (YL) \, (P_{cs}) - CV_{\underset{I}{cs}} - CI_{\underset{I}{cs}}) \, (ARP_c/(1-ARP_c)) \\
& - CC_s \, (ARP_c/(1-ARP_c))]
\end{aligned}
$$

(2) Returns per dryland acre:

$$
\begin{aligned}
NRAC_{\underset{D}{c's}} = {} & (1-R_{\underset{D}{c's}}) \, [Y_{\underset{D}{c's}} (P_{c's}) - CV_{c's}] \\
& + R_{\underset{D}{c's}} \, [Y_{\underset{D}{c's}} (P_{c's} + LS_{c's}) + YP_{\underset{D}{c's}} (DP_{c'}) \, (1/X_{\underset{D}{c's}}) - CV_{\underset{D}{c's}} \\
& - (Y_{\underset{D}{c's}} (YL) \, (P_{c's}) - CV_{\underset{D}{c's}}) \, (ARP_{c'}/(1-ARP_{c'})) \\
& - CC_s \, (ARP_{c'}/(1-ARP_{c'}))]
\end{aligned}
$$

(3) Returns to irrigation (per acre-foot of applied water):

$$
NRAF_{\underset{I}{cs}} = (NRAC_{\underset{I}{cs}} - NRAC_{\underset{D}{c's}}) \, / \, W_{\underset{I}{cs}}
$$

Symbols

Parameters

ARP	Base acreage set-aside requirement (percent)
CC	Compliance cost per acre set-aside
CI	Variable irrigation costs per harvested acre
CV	Variable (nonirrigation) production costs per harvested acre
DP	Deficiency payment rate (per unit program yield)
LS	Loan rate support (where loan rate exceeds market price)
NRAC	Average net return (total revenue less variable costs) per harvested crop acre
NRAF	Average net return to irrigation per acre-foot of applied water
P	Market price
R	Harvested acreage enrolled in commodity programs as a share of total harvested acreage (percent)
W	Average water application (af per acre)
X	Acreage expansion factor (planted/harvested acres)
Y	Average yield per harvested acre
YL	Yield adjustment factor for less productive ARP set-aside lands
YP	Average per-acre program yield

Subscripts

C	Crop
C'	Representative dryland crop alternative
D	Dryland
I	Irrigated
S	State

Appendix table 1 -- Distribution of harvested field-crop acreage by western region and crop, irrigated and dryland, 1984 and 1987

1,000 acres

1984 Irrigated	Wheat	Corn	Sorghum	Soybean	Cotton	Rice	Oats	Barley	Alfalfa	Other-hay	Total
N. Plains	742	4,664	721	986	0	0	20	52	689	84	7,959
S. Plains	1,009	682	670	57	1,620	408	12	39	177	85	4,757
N. Mountain	1,003	823	84	0	0	0	128	1,207	2,572	1,699	7,515
S. Mountain	259	64	63	0	498	0	0	110	632	288	1,914
N. Pacific	412	185	0	0	0	0	25	154	753	575	2,103
S. Pacific	521	278	43	0	1,400	450	25	216	975	212	4,120
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Westwide	3,946	6,696	1,580	1,042	3,518	858	210	1,777	5,798	2,943	28,368

1984 Dryland	Wheat	Corn	Sorghum	Soybean	Cotton	Rice	Oats	Barley	Alfalfa	Other-hay	Total
N. Plains	25,030	6,654	5,823	5,254	0	0	2,950	3,676	5,901	6,746	62,034
S. Plains	9,291	918	3,730	573	3,455	0	318	51	353	4,365	23,056
N. Mountain	8,700	23	346	0	0	0	154	1,993	1,368	1,201	13,786
S. Mountain	367	25	233	0	0	0	0	0	63	117	805
N. Pacific	3,313	7	0	0	0	0	80	1,106	167	410	5,084
S. Pacific	263	97	5	0	0	0	25	244	45	298	977
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Westwide	46,964	7,725	10,138	5,828	3,455	0	3,527	7,071	7,897	13,137	105,742

1987 Irrigated	Wheat	Corn	Sorghum	Soybean	Cotton	Rice	Oats	Barley	Alfalfa	Other-hay	Total
N. Plains	631	5,323	674	891	0	0	21	50	617	74	8,281
S. Plains	815	581	567	53	1,506	269	11	26	191	92	4,111
N. Mountain	940	803	61	0	0	0	110	1,075	3,490	2,530	9,009
S. Mountain	222	61	56	0	351	0	0	66	583	276	1,615
N. Pacific	385	100	0	0	0	0	13	134	739	569	1,940
S. Pacific	466	164	18	0	1,141	370	1	180	1,064	232	3,636
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Westwide	3,459	7,032	1,376	944	2,998	639	156	1,531	6,685	3,772	28,592

1987 Dryland	Wheat	Corn	Sorghum	Soybean	Cotton	Rice	Oats	Barley	Alfalfa	Other-hay	Total
N. Plains	23,882	5,307	4,646	5,474	0	0	2,344	3,895	5,491	6,219	57,258
S. Plains	7,585	736	2,493	327	3,294	0	270	29	399	4,768	19,901
N. Mountain	7,932	19	169	0	0	0	145	2,356	1,352	1,199	13,172
S. Mountain	228	8	95	0	0	0	0	0	47	104	482
N. Pacific	2,440	4	0	0	0	0	88	732	163	409	3,836
S. Pacific	101	57	2	0	0	0	39	150	50	324	723
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Westwide	42,168	6,131	7,405	5,801	3,294	0	2,886	7,162	7,502	13,023	95,372

Source: Agricultural Statistics, USDA

Appendix table 2 -- Representative dryland production alternatives by irrigated crop, seventeen western states

Dryland crop alternatives by State 1/	Irrigated crops									
	Wheat	Corn	Soybean	Cotton	Sorghum	Rice	Barley	Oats	Alfalfa	Other-hay
Northern Plains										
North Dakota	Wht	Corn	Soy	--	--	--	Barl	Oats	Alf	Ohay
South Dakota	Wht	Corn	Soy	--	--	--	Barl	Oats	Alf	Ohay
Nebraska	Wht	Sorg	Soy	--	Sorg	--	Barl	Oats *	Alf	Ohay
Kansas	Wht *	Sorg *	Soy *	--	Sorg *	--	Barl *	Oats *	Alf *	Ohay *
Southern Plains										
Oklahoma	Wht *	Sorg	Soy	Cot	Sorg	--	Barl *	Oats	Alf *	Ohay *
Texas	Wht	Sorg *	Sorg *	Cot	Sorg *	Sorg	Barl	Oats *	Alf *	Ohay
Northern Mountain										
Montana	Wht	Wht *	--	--	--	--	Barl	Oats	Alf	Ohay
Idaho	Wht	Wht	--	--	--	--	Barl	Oats	Alf *	Ohay *
Wyoming	Wht	Wht	--	--	--	--	Barl	Oats *	Alf	Ohay
Colorado	Wht	Wht	--	--	Sorg	--	Barl	Oats	Alf	Ohay
Utah	Wht	Wht	--	--	--	--	Barl	Oats	Alf	Ohay
Southern Mountain										
New Mexico	Wht	Sorg	--	Wht	Sorg	--	Barl	Oats	Alf	Ohay
Arizona	x	x	--	x	x	--	x	x	x	x
Nevada	x	--	--	--	--	--	x	x	x	x
Northern Pacific										
Washington	Wht *	Wht *	--	--	--	--	Barl *	Oats *	Alf *	Ohay *
Oregon	Wht	Wht	--	--	--	--	Barl	Oats *	Alf *	--
Southern Pacific										
California	Wht *	Wht	--	Wht *	Sorg	Wht	Barl *	Oats	Alf *	--

-- = Irrigated acreage for a given crop was negligible.
* = State-average dryland yields (actual and program) were reduced by 10% in estimating returns to dryland crop alternatives.
x = Dryland production was generally not feasible (i.e., dryland opportunity costs for irrigated production are zero).

Appendix table 3 -- Harvested acreage in commodity programs as a share of total harvested acreage in eligible program crops, by region and crop, irrigated and dryland, 1984 and 1987

	1984			1987		
	Irrigated enrollment as a share of total irrigated 1/	Dryland enrollment as a share of total dryland	Total enrollment as a share of total harvested cropland	Irrigated enrollment as a share of total irrigated	Dryland enrollment as a share of total dryland	Total enrollment as a share of total harvested cropland
	Percent					
All program crops, westwide:	48	47	47	87	84	84
All program crops, by western region:						
N. Plains	56	48	49	98	87	89
S. Plains	61	45	48	88	72	75
N. Mountain	35	49	46	76	86	83
S. Mountain	50	48	50	72	57	63
N. Pacific	27	40	38	79	91	89
S. Pacific	28	13	25	76	41	71
By program crop, westwide:						
Wheat	42	49	49	84	85	85
Corn	52	51	52	97	93	95
Sorghum	41	39	39	86	78	79
Cotton	55	80	67	83	90	86
Rice	89	--	89	92	--	92
Barley	20	38	34	64	84	81
Oats	3	14	13	13	48	47

1/ Actual enrollment rates for irrigated and dryland acreage were not available for 1984. For this study, irrigated and dryland enrollment shares for 1984 were estimated based on reported irrigated/dryland shares by crop for 1987, and cropping patterns and total enrollment shares by crop for 1984.

Source: ASCS enrollment data and NASS harvested acres.

Appendix table 4 -- Market price, target price, loan rate, deficiency payment rate, and ARP set-aside requirement - by crop, U.S., 1982-93

Crop	Unit	Item 1/	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
			Production year											
Wheat	$/bu	mrkt	3.45	3.51	3.39	3.08	2.42	2.57	3.72	3.72	2.61	3.00	3.24	3.20
	$/bu	trgt	4.05	4.30	4.38	4.38	4.38	4.38	4.23	4.10	4.00	4.00	4.00	4.00
	$/bu	loan /2	3.55	3.65	3.30	3.30	2.40	2.28	2.21	2.06	1.95	2.04	2.21	2.45
	$/bu	def	0.50	0.65	1.00	1.08	1.98	1.81	0.69	0.32	1.28	1.35	0.81	1.03
	.xx	ARP /3	0.15	0.15	0.20	0.20	0.225	0.275	0.275	0.10	0.05	0.15	0.05	0.00
Corn	$/bu	mrkt	2.55	3.21	2.63	2.23	1.50	1.94	2.54	2.36	2.28	2.37	2.07	2.55
	$/bu	trgt	2.70	2.86	3.03	3.03	3.03	3.03	2.93	2.84	2.75	2.75	2.75	2.75
	$/bu	loan	2.55	2.65	2.55	2.55	1.92	1.82	1.77	1.65	1.57	1.62	1.72	1.72
	$/bu	def	0.15	0.00	0.43	0.48	1.11	1.09	0.36	0.58	0.51	0.41	0.73	0.28
	.xx	ARP	0.10	0.10	0.10	0.10	0.175	0.20	0.20	0.10	0.10	0.075	0.05	0.10
Cotton	$/cwt	mrkt	59.60	65.60	58.90	56.30	52.40	64.30	56.60	66.20	67.10	58.10	54.90	58.00
	$/cwt	trgt	71.00	76.00	81.00	81.00	81.00	79.40	75.90	73.40	72.90	72.90	72.90	72.90
	$/cwt	loan	57.00	55.00	55.00	57.30	55.00	52.25	51.80	50.00	50.27	47.23	43.80	49.00
	$/cwt	def	13.92	12.10	18.60	23.70	26.00	17.30	19.40	13.10	7.30	10.10	20.30	19.40
	.xx	ARP	0.15	0.20	0.25	0.20	0.25	0.25	0.125	0.25	0.125	0.05	0.10	0.075
Rice	$/cwt	mrkt	7.91	8.57	8.04	6.53	3.75	7.27	6.83	7.35	6.70	7.58	5.89	8.50
	$/cwt	trgt	10.85	11.40	11.90	11.90	11.90	11.66	11.15	10.80	10.71	10.71	10.71	10.71
	$/cwt	loan	8.14	8.14	8.00	8.00	7.20	5.79	6.21	6.00	5.40	5.85	4.70	5.75
	$/cwt	def	2.71	2.77	3.76	3.90	4.70	4.82	4.31	3.56	4.16	3.07	4.21	4.21
	.xx	ARP	0.15	0.15	0.25	0.20	0.35	0.35	0.25	0.25	0.20	0.05	0.00	0.05
Sorghum	$/bu	mrkt	2.47	2.74	2.32	1.93	1.37	1.70	2.27	2.10	2.12	2.25	1.89	2.35
	$/bu	trgt	2.60	2.72	2.88	2.88	2.88	2.88	2.78	2.70	2.61	2.61	2.61	2.61
	$/bu	loan	2.75	2.52	2.42	2.42	1.82	1.74	1.68	1.57	1.49	1.54	1.63	1.63
	$/bu	def	0.18	0.00	0.46	0.46	1.06	1.14	0.48	0.66	0.56	0.37	0.72	0.25
	.xx	ARP	0.10	0.10	0.10	0.10	0.175	0.20	0.20	0.10	0.10	0.075	0.05	0.05
Barley	$/bu	mrkt	2.18	2.47	2.29	1.98	1.61	1.81	2.80	2.42	2.14	2.10	2.04	2.00
	$/bu	trgt	2.60	2.60	2.60	2.60	2.60	2.60	2.51	2.44	2.36	2.36	2.36	2.36
	$/bu	loan	2.08	2.16	2.08	2.08	1.56	1.49	1.44	1.34	1.28	1.32	1.40	1.40
	$/bu	def	0.40	0.21	0.26	0.52	0.99	0.79	0.00	0.00	0.20	0.62	0.56	0.67
	.xx	ARP	0.10	0.10	0.10	0.10	0.175	0.20	0.20	0.10	0.10	0.075	0.05	0.00
Oats	$/bu	mrkt	1.49	1.62	1.67	1.23	1.21	1.56	2.61	1.49	1.14	1.21	1.32	1.35
	$/bu	trgt	1.50	1.60	1.60	1.60	1.60	1.60	1.55	1.50	1.45	1.45	1.45	1.45
	$/bu	loan	1.31	1.36	1.31	1.31	0.99	0.94	0.91	0.85	0.81	0.83	0.88	0.88
	$/bu	def	0.00	0.11	0.00	0.29	0.39	0.20	0.00	0.00	0.32	0.35	0.17	0.11
	.xx	ARP	0.10	0.10	0.10	0.10	0.175	0.20	0.05	0.05	0.05	0.00	0.00	0.00
Soybean	$/bu	mrkt	5.71	7.83	5.84	5.05	4.78	5.88	7.42	5.69	5.74	5.58	5.56	6.45
		loan	5.02	5.02	5.02	5.02	5.02	4.77	4.77	4.53	4.50	5.02	5.02	5.02
Alfalfa	$/ton	mrkt	69.80	79.10	73.90	70.70	58.80	67.60	89.40	90.50	91.00	72.10	75.00	84.30
Other hay	$/ton	mrkt	54.70	57.80	60.90	58.60	52.70	51.80	70.60	65.50	65.10	56.60	57.00	60.90

1/ mrkt = U.S. season-average market price; trgt = target price; loan = loan rate; def = deficiency payment rate; ARP = base acreage set-aside requirement.

2/ 1982-85, basic loan rate; 1986-93, basic loan rate for cotton / announced (Findley) loan rate for all other.

3/ Additional set-asides were provided for certain crops in selected years under the Payment-in-Kind Program and Paid-Land-Diversion Program.

Source: Agricultural Outlook, USDA; Agricultural Statistics, USDA

Appendix table 5 -- Average water applied per acre in western irrigated field-crop production, by region and crop, 1984 and 1987

Year	Western region	Irrigated crops										
		Wheat	Corn	Sorghum	Soybean	Cotton	Rice	Oats	Barley	Alfalfa	Other-hay	Total
		(acre-feet / acre)										
1984	N. Plains	0.95	1.16	1.20	0.81	--	--	0.84	0.85	1.30	1.36	1.11
	S. Plains	1.01	1.80	1.22	1.60	0.91	3.10	1.00	0.96	2.30	1.14	1.36
	N. Mountain	1.40	1.78	1.10	--	--	--	1.47	1.50	1.91	1.67	1.69
	S. Mountain	2.65	2.90	2.24	--	4.55	--	--	2.76	3.48	2.17	3.35
	N. Pacific	1.70	2.52	--	--	--	--	1.57	1.54	2.20	1.95	2.01
	S. Pacific	2.00	3.20	1.90	--	3.00	5.70	1.50	1.70	3.80	1.70	3.22
	Westwide	1.41	1.44	1.26	0.86	2.26	4.46	1.40	1.57	2.37	1.75	1.83
1987	N. Plains	0.91	1.19	1.04	0.84	--	--	0.76	0.61	1.21	0.92	1.11
	S. Plains	0.99	1.69	1.15	0.94	0.84	3.01	0.85	0.81	1.71	0.91	1.22
	N. Mountain	1.43	1.89	1.56	--	--	--	1.60	1.54	1.89	1.50	1.68
	S. Mountain	2.27	2.36	1.83	--	4.61	--	--	2.27	3.51	1.77	3.13
	N. Pacific	1.61	2.73	--	--	--	--	1.63	1.50	2.27	1.96	2.02
	S. Pacific	1.99	3.03	2.51	--	3.20	5.26	1.43	1.62	3.90	2.17	3.30
	Westwide	1.38	1.39	1.16	0.85	2.18	4.31	1.43	1.53	2.33	1.60	1.76

Source: 1984 Farm and Ranch Irrigation Survey
1987 ERS estimates (Quinby, unpublished)

Appendix table 6 -- Average variable cost, market return, and commodity program revenue contribution per irrigated field-crop acre, by western region and crop westwide, 1984 and 1987 1/ 2/

		(1) Variable irrigation cost per acre	(2) Total variable cost (TVC) per acre	(3) Market revenue per acre	(4) Commodity program revenue per acre	(5) Market return above TVC per acre (3)-(2)	(6) Combined return above TVC per acre (4)+(5)	(7) Program revenue as a share of combined revenue (4)/(3+4)
		$/ac	$/ac	$/ac	$/ac	$/ac	$/ac	Pcnt
1984	All field crops, westwide	59.50	209.90	312.00	28.20	102.10	130.30	8.3
	All field crops, by western region							
	N. Plains	48.30	173.70	290.70	19.20	117.00	136.20	6.2
	S. Plains	64.80	223.20	300.40	62.20	77.20	139.40	17.2
	N. Mountain	47.00	134.90	223.50	6.50	88.60	95.10	2.8
	S. Mountain	97.60	321.40	402.40	39.60	81.00	120.60	9.0
	N. Pacific	55.40	183.10	293.70	5.00	110.60	115.60	1.7
	S. Pacific	82.20	363.20	495.50	52.70	132.30	185.00	9.6
	By field crop, westwide							
	Wheat	49.30	169.20	238.30	22.00	69.10	91.10	8.5
	Corn	58.80	219.10	367.20	22.30	148.10	170.40	5.7
	Sorghum	51.70	154.10	224.90	18.60	70.80	89.40	7.6
	Cotton	68.10	379.10	492.50	90.10	113.40	203.50	15.5
	Rice	110.90	378.40	449.40	248.70	71.00	319.70	35.6
	Barley	44.30	141.50	207.90	3.00	66.40	69.40	1.4
	Oats	36.30	115.20	130.00	0.00	14.80	14.80	0.0
	Soybeans	39.30	111.10	206.10	--	95.00	95.00	--
	Alfalfa hay	73.90	202.10	345.20	--	143.10	143.10	--
	Other hay	43.00	120.70	124.70	--	4.00	4.00	--
1987	All field crops, westwide	55.40	194.50	272.80	63.60	78.30	141.90	18.9
	All field crops, by western region							
	N. Plains	47.50	174.90	246.80	93.10	71.90	165.00	27.4
	S. Plains	58.40	211.60	281.30	90.90	69.70	160.60	24.4
	N. Mountain	43.90	125.90	170.60	23.30	44.70	68.00	12.0
	S. Mountain	90.30	297.00	391.10	46.00	94.10	140.10	10.5
	N. Pacific	54.10	174.70	240.00	29.60	65.30	94.90	11.0
	S. Pacific	83.50	354.50	540.40	91.80	185.90	277.70	14.5
	By field crop, westwide							
	Wheat	46.80	163.80	178.00	86.90	14.20	101.10	32.8
	Corn	56.90	212.00	291.20	119.50	79.20	198.70	29.1
	Sorghum	46.60	146.70	154.10	92.70	7.40	100.10	37.6
	Cotton	63.40	357.90	616.90	114.30	259.00	373.30	15.6
	Rice	108.10	366.80	494.20	247.90	127.40	375.30	33.4
	Barley	41.80	135.80	176.00	32.80	40.20	73.00	15.7
	Oats	35.70	107.30	112.30	1.60	5.00	6.60	1.4
	Soybeans	37.60	109.90	243.80	--	133.90	133.90	--
	Alfalfa hay	66.80	187.30	280.10	--	92.80	92.80	--
	Other hay	38.80	109.50	97.90	--	-11.60	-11.60	--

1/ Estimates are acreage-weighted across program and nonprogram production.
2/ Crop returns per irrigated acre are in contrast with returns to irrigation per unit-water (table 1), which were calculated net of dryland cost/returns.

Appendix figure 1

Average cost and return per irrigated field-crop acre